12-1987

A Comparison of the Pattern of Involvement of Degenerative Joint Disease Between an Agricultural and Non-Agricultural Skeletal Series

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To the Graduate Council:

I am submitting herewith a dissertation written by Lorna Kathryn Collins Pierce entitled "A Comparison of the Pattern of Involvement of Degenerative Joint Disease Between an Agricultural and Non-Agricultural Skeletal Series." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

William M. Bass, Major Professor

We have read this dissertation and recommend its acceptance:

Francis S. Jones, R.L. Jantz, Walter E. Klippel

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A COMPARISON OF THE PATTERN OF INVOLVEMENT OF DEGENERATIVE JOINT DISEASE BETWEEN AN AGRICULTURAL AND NON-AGRICULTURAL SKELETAL SERIES

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Lorna Kathryn Collins Pierce

December 1987

Acknowledgments

Numerous individuals have contributed both directly and indirectly to the preparation and completion of this research. Foremost among these are the members of my Dissertation Committee, Dr. William M. Bass, Dr. Richard L. Jantz, Dr. Francis S. Jones, and Dr. Walter E. Klippel who agreed to assist and guide me along the way. Dr. Bass and Dr. P. Willey graciously allowed me to examine the skeletal collection from Averbuch which is housed at the University of Tennessee and Dr. George Milner extended to me the same privilege for the Indian Knoll collection at the University of Kentucky in Lexington. Ann Reed answered my computer questions and the entire staff of the Inter-library Loan Department of the University of Tennessee expedited my every request.

The constraints of space preclude my thanking all the friends and colleagues who assisted and encouraged me along the way, however there are a few who require special mention here for the prominent roles they have played. Two very special friends who kept me on the straight and narrow path were Catherine Goldsmith and Charles Wasserman. Among those to whom I am deeply grateful is my friend, Dr. Robert D. Jurmain, for his encouragement as well as for his gracious permission to use his original artwork in the Appendix.

Finally, and most importantly, my deepest gratitude goes to the two people without whose support, encouragement, and constant understanding I would not have completed this undertaking, my husband, Wilbur R. Pierce Jr., and my best friend, Stratos Guiliotis.

ABSTRACT

This study investigates the differences in the pattern of involvement of osteoarthritis between two groups of prehistoric American Indians who lived in a similar ecosystem and climate, separated by time and cultural activities. The purpose of this biocultural investigation was to determine if there was a difference in the patterning of the degenerative lesions in the two skeletal series and if that suite of characteristics would assist in determining possible aetiological factors and culturally determined activities.

Two archaeological skeletal series were utilized, Averbuch (40DV60), of middle Tennessee, to represent an agricultural site outside the mainstream of the late Mississippian period and Indian Knoll (24OH2), in Kentucky, an Archaic series. A detailed examination of the adult osseous remains was undertaken employing a sample of 196 individuals from Averbuch and 199 from Indian Knoll; observations were made bilaterally on forty-five discrete areas of the the four large peripheral joints. The statistical analysis of the discrete variables as well as those of the total joints, knee, hip, shoulder, and elbow are discussed at length.

A distinct difference in the pattern of

involvement of degenerative joint disease was evident, the Averbuch individuals exhibited a highly statistically significant greater involvement than the Indian Knoll individuals. Averbuch exhibited evidence of an earlier onset of degenerative changes and a higher degree of severity than Indian Knoll within all joints.

The degenerative changes indicate that the females of both sample populations utilized the shoulder in comparable fashion although the Averbuch women manifested evidence of more stressful behavior at all ages.

Biological and social evidence of stress indicate that factors other than culturally determined physical activities existed which contributed to the generally more adversarial climate in which the Averbuch people survived.

The results of this study emphasize the adverse effect which agriculture and its attendant modifications in cultural activities may have on the human species.

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CHAPTER I

INTRODUCTION

Degenerative joint disease has been the bane of humankind's existence from time immemorial. Skeletal remains from early sites display evidence that our ancestors suffered from osteoarthritis* just as modern populations do. The human fossil record indicates that osteoarthritic lesions appeared in the Krapina, Yugoslavia Neanderthal population between 125,000 and 70,000 years ago (Smith 1976). Minugh (1982) considers this as a minimum date of onset since earlier examples of osteoarthritis may not have been preserved or have not been discovered. The paucity of evidence may also be an artifact due to the early mortality of our ancestors. Evidence of this disease has been found in the remains of the fossils from La Chapelle-aux-Saints as well as in individuals from the Paleolithic and Neolithic times (Vallois 1949, Angel 1952, Ackerknecht 1957, Straus and Cave 1957). In fact, the most common pathological lesions found in human remains are those of appendicular

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* Degenerative joint disease and osteoarthritis shall be used interchangably during the course of this paper, and shall refer only to the lesions affecting diarthrodial joints of the appendicular skeleton. The disease process referred to as primary osteoarthritis will be addressed, not secondary osteoarthritis.

osteoarthritis, vertebral osteoarthritis, and vertebral osteophytosis; they are found in human skeletal remains from every time period and every geographical area of the globe (Isdale 1975, Steinbock 1976).

Indeed most vertebrate species, both modern and pre-Holocene, develop osseous evidence of joint changes that correspond with the lesions found in osteoarthritic joints of human beings (Fox 1939, Adams and Billingham 1982). Moodie (1967:41) states that "Arthritides are especially common in Pleistocene mammals." Osteoarthritis is often found in the feet of cattle from archaeological sites (Baker and Brothwell 1980).

It is estimated that although degenerative joint disease begins in the twentieth year it is almost universal by age 70 (Cobb 1971, Moskowitz 1979). It is the most common disorder of movable joints (Beute 1979). The 1979 publication of the National Center for Health Statistics indicated that an estimated ten percent of the civilian non-institutionalized United States population between the ages of twenty-five and seventy-four had been treated for arthritis of the knees, hip or sacroiliac joint during the period 1971-1975 (Maurer 1979). This figure should not be considered to be the prevalence rate for degenerative joint disease since it has been established that extensive damage to the joint may occur without symptoms being reported (Acheson 1983).

As a result of the high prevalence rate of osteoarthritis in the human species, thousands of reports have been published on this potentially debilitating disease. The majority have been descriptive with no attempt at comparison. The publications can be classified into two major groups; medical reports and anthropological reports. The medical studies group can be further divided into two groups; autopsy reports and epidemiological studies. The autopsy reports and epidemiological publications have been systematically and extensively reviewed by many researchers, and to reiterate them here would be redundant. The data from the epidemiological reports will be utilized in Chapters Five through Nine which deal with the results and discussion of this present study; however for excellent and comprehensive literature reviews of both the autopsy and epidemiological reports dealing with osteoarthritis please see Jurmain (1975) and Sokoloff (1969, 1980a, 1980b). Two recent collections of papers concerning current research in this field are Clinical Pathologic Osteoarthritis Workshop (1983) and Osteoarthritis, edited by Sokoloff (1985).

Early anthropological reports often contained references to osteoarthritic lesions either in the body of a skeletal analysis report or as an addendum in an appendix. About twenty years ago populational or epidemiological theory began to insinuate itself into anthropological studies with excellent results. These biocultural models dealt with the interaction of culture and skeletal biology and the practicality of interpreting skeletal analysis as a component of the cultural entity. E. A. Hooten's The Indians of Pecos Pueblo (1930), J. Lawrence Angel's many publications, particularly The People of Lerna (1971), and Charles Merbs' Patterns of Activity-Induced Pathology in a Canadian Inuit Population (1983) are excellent examples of biocultural studies utilizing skeletal populations, and examining many aspects of paleopathology of a particular skeletal series. Other researchers such as Tainter (1980) and Kilgore (1984) have considered one particular aspect of paleopathology, osteoarthritis, of a skeletal group. The latest result of the evolution of populational studies has been to utilize comparative data between populations to attempt to reconstruct culturally induced activities, and to compare health, nutrition, and stress between groups separated both temporally and spatially (Jurmain 1975, Pickering 1984).

A wide variety of stress indicators has been examined by various researchers; degenerative joint disease (Jurmain 1975, Kilgore 1984), growth arrest lines (McHenry 1968, Cook 1979), dental asymmetry (Perzigian 1977, Harris and Nweeia 1980), enamel developmental disturbances (Cook and Buikstra 1979), nutritional stress (Lallo 1973, El-Najjar et al. 1976). An excellent summary of palaeopathological studies prior to 1980 can be found in Buikstra and Cook (1980).

This study investigates the differences in the pattern of involvement of osteoarthritis between two groups of prehistoric American Indians who lived in a similar ecosystem and climate, separated by time and cultural activities. The differences in patterning should assist in making a statement about possible aetiological factors and cultural activities.

In recent years anthropological studies utilizing several methods of skeletal analysis have been implemented to describe the parameters and differences in the health, nutrition, and other stresses of agriculturalists and non- or pre-agriculturalists, (Cassidy 1972, 1980, Milner 1982, Cohen and Armelagos 1984, Huss-Ashmore et al. 1982). Martin (1983) utilized microstructural analysis of bone remodeling to evaluate the health of a Nubian population. Cassidy (1972) and Milner (1982) utilized radiographs to study growth arrest lines in American Indian populations. Lallo (1973) used anthropometrics to evaluate growth.

Guagliardo (1982) used tooth crown size as a possible indicator of stress. Nitrogen and carbon isotope ratios in bone collagen have been examined in an attempt to reconstruct prehistoric diets (Walker and DeNiro 1986).

The last few decades have seen the rise of two new specialties in the field of medicine, the industrial and sports fields. Both groups are concerned with the implications of stressful and repetitive activities on the human body; osteoarthritis is one of the disease entities addressed in these fields.

Culturally determined activities may induce certain patterns of involvement of degenerative joint disease. The similarities and differences between the patterns of involvement of similar but not identical movements may be an indication of culturally induced activities. For example the way the elbow is used in the following motions is similar but not identical, and the pattern of involvement of osteoarthritis lesions is also similar yet different; i.e. throwing a baseball, an atlatl, a football, a harpoon.

If the culturally determined activities are different between populations, there may be a difference in pattern. This study was predicated upon the following hypotheses:

1. There will be a difference in the pattern of

involvement of degenerative joint disease between agricultural and gatherer-hunter populations in prehistoric cultures.

2. If there is added nutritional and activity stress due to the change to incipient agriculture, the degree of involvement will be greater.

Changes in activity patterns will include the utilization of joints in different fashions. If there is nutritional stress (as has been shown in other studies of early agriculturalists) then all other aspects of disease and stress may be intensified (See Cohen and Armelagos, 1984). The results may suggest what cultural activities and areas of stress were prevalent within the different groups.

CHAPTER II

THE BIOLOGY OF THE NORMAL AND DISEASED JOINT

The Normal Joint

Articular Cartilage

Normal articular cartilage, a specialized form of connective tissue, is formed embryologically from mesenchymal tissue. The resultant hyaline cartilage covers the articulating ends of bones and is uniquely suitable for providing a gliding surface for lubrication and joint movement, and is resistant to mechanical stress of both load bearing and shearing stress (Mankin 1974a, Minns 1976, Minns *et al*. 1977, Weiss 1979). It is, however, sensitive to breakdown from tensile forces (Radin 1976).

Articular cartilage consists of a matrix composed of a fibrous component, collagen, with a filler of proteoglycan ground substance (Mankin 1976, Weiss 1979). The matrix is a network of collagen fibers which are responsible for the maintenance of the shape of the cartilage (Schofield and Weightman 1978) and which supply the tensile properties of articular cartilage (Muir 1978, Weiss 1979). The collagen fibers also attach the ground substance to the underlying bone. The collagen of articular cartilage is a different type from that found in skin and bone; it is composed of three chains of a1 (II) instead of two a1 (I) and one a2 chains (Mankin 1976, Goldwasser et al. 1982).

The proteoglycan ground substance fills the cartilage network and is composed of three glycosaminoglycans: chondroitin-4-sulfate, chondroitin-6-sulfate, and keratan sulfate (Weiss 1979). Chondroitin 6-sulfate is responsible for over 45-75% of the sugar component (Mankin 1976). The proteoglycans are responsible for elasticity and resistance to compression (Schofield and Weightman 1978).

Articular cartilage is avascular, aneural, alymphatic, and rather hypocellular (Salter and Field 1960, Mankin 1976, Moskowitz 1977, Weiss 1979). As a result it is in effect isolated from the body's vascular system which limits the pathways of nutrition. The source of nutrition for the cartilage is the diffusion of nutrients from the synovium, and in immature cartilage, from the subchondral bone (Mankin 1974a, Salter and Field 1960, Hulth 1982). Diffusion of nutrients is increased by the normal use of the joint.

The articular tissue is hyperhydrated being composed of 75-80% water; this high content is important to resiliency and to the lubrication of the joints (Mankin

1974b, 1982) and to the spongy nature of the cartilage (Bollet 1969).

Contrary to the hypotheses of early researchers, articular cartilage is metabolically active, not inert (Mankin 1974a, 1976). Chondrocytes regularly synthesize the molecules of the matrix and the proteoglycans for their maintenance (Mitrovic et al. 1983). Studies by Lippiello et al. (1977) suggest that a small portion of the proteoglycans has rapid turnover.

There are four zones of articular cartilage: tangential, transitional, radial, and calcified (Weiss 1979). The arrangement of cells differs among the layers; the tensile properties also vary from level to level (Freeman 1975). There is an increased rate of matrix synthesis with age which creates changes in the cells of all zones. The cell density decreases with age and zone (Mitrovic et al. 1983). The articular surface contains more collagen than the deeper layers (Bullough 1979).

There is variation in the thickness of articular cartilage from one to five millimeters; the center of convex surfaces and the periphery of concave surfaces have a greater thickness (Bullough 1979). The thickness of femoral head cartilage increases from age twenty to age fifty (Gardner 1979).

Synovial Fluid

The synovial fluid is a clear dialysate of blood plasma plus hyaluronate (Salter and Field 1960, Mankin 1976); the hyaluronate provides the high viscosity element of the fluid (Bullough 1979). The volume of synovial fluid within each joint is quite small; the knee, which is the largest joint in the human body, contains only four milliliters (McCarty 1979).

The exact rheological concepts of joint lubrication are not fully understood although recent experiments on animal models are beginning to illuminate the darkness (Lee et al. 1974). Current thought considers two principles:

(1) compression of cartilage squeezes out fluid; the cartilage weeps, the compression ceases, and the fluid is resorbed

(2) the synovial fluid creates a boundary level to reduce friction. The mucin fraction exuded by the synovial tissue is the boundary lubricant (Sokoloff 1969, Lee et al. 1974, McCutchen 1978, Ilardi and Sokoloff 1981). The least understood component of joint lubrication is how the mucin achieves the lubrication (McCutchen 1978). (For an extensive discussion of current thought, see Sokoloff 1978, 1980b, 1985).

Synovial Membrane

The synovial membrane which lines the inner surface of the joint capsule, is composed of modified mesenchymal tissue (Bullough 1979, Trueta 1968, Hirohata 1974). This vascular connective tissue has a remarkable capacity to regenerate itself; repair can be complete thirty to one hundred days after synovectomy (Bennett 1966b). Passage of material between blood, lymph, and synovial fluid is regulated by the membrane; it also produces the mucin, a non-sulfate mucopolysaccharide which gives synovial fluid its viscous quality (Trueta 1968, Bennett 1966b).

Studies utilizing the electron microscope have disclosed two principal types of synovial cells, A and B, plus a much less frequent type termed an intermediate. Apparently cell A acts as a phagocyte while cell B synthesizes hyaluronate (Bullough 1979). There is an apparent increase in the number of type B cells and intermediate cells present when the synovial membrane is irritated (Van Sickle and Kincaid 1978).

Hamerman (1983) discusses a recent hypothesis that interleukin-1 may be released by the macrophage type synovial cells and that the interleukin may activate other cells to produce products capable of destroying cartilage matrix.

Bone

Bone is composed of a highly specialized connective tissue comprised of an organic matrix of approximately 95% collagen and the remainder of mucopolysaccharides and a small amount of lipoproteins. A ground substance of water, a variety of ions, proteoglycans, and glycoproteins fills the area between the collagen fibrils and the hydroxyapatite crystals (Bennett 1966a, Pritchard 1979, Ortner and Putschar 1981, Shipman, et al. 1985).

Bones serve three main functions in the mammalian body; mechanical, mineral, and hemopoietic. Although the mechanical function is of primary concern in this research project, the functions are all inter-related. Bones provide the rigid framework for both the weight-bearing columns and the lever system utilized in the joints, as well as providing a protective shell for the internal organs. Bones also function as mineral repositories to store calcium and phosphate ions; these are withdrawn automatically when the body cells' concentrations fall low. The bone marrow in most bones except the shafts of adult long bones is engaged in hematopoiesis.

Of the three morphological types of bone; compact, cancellous, and subchondral, the subchondral bone occurs in the diarthrodial joint and underlies the hyaline cartilage at the tidemark (Shipman et al. 1985).

Subchondral bone is highly vascularized and serves as a shock absorber within the joint (Hughes 1979, Shipman et al. 1985).

The Aging of Joints

The pathological changes of osteoarthritis should be differentiated from normal senescent changes affecting the tissues of the joint. Yoshikawa et al. state that the aging of bone is "...a manifestation of the progressive redistribution of the mineral and connective tissue component in the whole organism in the process of aging."(1974:127). There are age changes on the bony surfaces of the pubic symphysis which are so regular that they are utilized to age skeletal remains in both the archaeological and forensic fields (McKern and Stewart 1957, Suchey 1979, Katz and Suchey 1986). Age changes within the shoulder, specifically the glenoid fossa, may be used as corroborative evidence in the aging estimation (Graves 1922), as may changes in the auricular surface of the innominate (Lovejoy et al. 1985).

Although osteoarthritis is certainly age-related, it is not necessarily age dependent (Hamerman 1983, Huskisson and Hart 1973). The incidence of osteoarthritis, vertebral osteoarthritis, and osteophytosis all increase with age in every human population, however the prevalence and the pattern varies between populations (Hadler 1985). With an increase in age, the ability to cope with and to respond to stress may be impaired; age-related biochemical changes may lead to fatigue failure and impair the body's ability to heal lesions (Bollet 1969, King et al. 1982).

The most obvious early results of age changes within the joint capsule are the discoloration--from a bluish-white translucency to yellow to brown--and submicroscopic undulations in the surface of the articular cartilage (Barnett et al. 1963, Goodfellow and Bullough 1967, Tonna 1977); these changes are evident beginning in the third decade.

Anderson et al. (1964) found no significant change in the values for organic matrix after the age of ten. Apparently there is a decrease in the level of glycosaminoglycans in early childhood. Those same studies indicated a rise in collagen content until the fourth decade, then a decrease in the fifth decade.

The cell density in articular cartilage decreases significantly in the less than sixty year age group suffering from osteoarthritis, but the cell density of the osteoarthritic and normal subjects in the over sixty age group appears to be the same (Mitrovic 1983). Another similarity between senescent and osteoarthritic cartilage was found in a study of tissue types (Sachs et al. 1982). The three types of abnormal tissue found in osteoarthritic patients were also found in specimens over fifty years of age. The water content of aged articular cartilage decreases slightly, which is the opposite of what occurs in degenerative joint disease (Howell 1980). Evans and Georgescu (1983) suggest that a commonality between osteoarthritis and the aging of chondrocytes exists. In their work on articular cartilage from rabbits, dogs, and humans, they found that the "...population doubling capacity of cultures of these cells is directly related to the specific lifespan of the donor organism."(1983:179).

The deposition of calcium pyrophosphate salts in articular cartilage is very common in osteoarthritis and is strongly age-related. Deposition of these salts is radiographically apparent in fifty percent of people over ninety years while it is rare in those under fifty (Dieppe and Watt 1985).

The thickness of articular cartilage on femoral heads along the main load bearing areas of the hip joint increases with age from the third decade to the sixth decade (Gardner 1979), however cartilage from older specimens deforms much more easily than that from younger individuals.

It is possible to have more than one tidemark in the normal joint; indeed two or three is normal for those individuals over sixty years of age. There is an apparent thinning of the calcified cartilage in conjunction with the increased number of tidemarks with age (Bullough 1981).

The deformability of bone decreases with age, probably due to an increasing rigidity of the material. Camosso and Marotti (1962) utilized samples of bone plus cartilage and samples of only bone to compare variations in the deformability between age groups. The rigidity may be due to changes in the mineral content of the bone or to the osteosclerosis resulting from callus formation which results from the healing of microfractures in the subchondral bone.

Trueta and Harrison (1953) explored the common belief that vascular circulation decreases with age. In their examination of thirty-six femoral heads removed at autopsy, no evidence was found to support this hypothesis.

Osteoarthritis of the knee reaches its maximum severity at the age of sixty, there is no increase in the prevalence as the age increases from that point (Forman _et al_. 1983). Thus, although there is a definite relationship between age and this disease, aging is not inevitably accompanied by it; osteoarthritis of the knee will affect only a portion of the population (Kaplan 1983).

The Diseased Joint

The diarthrodial joint is composed of the articulating bone ends covered with hyaline cartilage, and enclosed in a fibrous capsule lined with the synovial membrane and lubricated with synovial fluid. These four elements; bone, cartilage, synovial fluid and synovial membrane are all affected by the onset and development of osteoarthritis, and the manifestations of the disease process are inter-related with these elements.

Osteoarthritis may result in the following damage to the affected joint: fibrillation of cartilage; removal of cartilage; exposed, grooved, or eburnated bone; superficial bone necrosis; sclerotic subchondral bone; cysts with fibromyxoid tissue; osteophytes on the non-weight bearing areas; subchondral fractures; villous proliferation, mild hyperplasia and chronic inflammation of the synovial membrane; loose bodies within the synovial fluid which in turn cause chronic hyperplastic synovitis (Tobin and Stewart 1953, Bullough 1979, Gardner 1983).

The diagnosis of osteoarthritis in a living patient is made by utilizing radiographs and is based on the criteria illustrated in the Atlas of Standard Radiographs (1963). There are differing opinions concerning the acceptance of other criteria such as pain, crepitus, and soft tissue swelling (Laine 1968). It is generally accepted that the earliest signs of degeneration of the joint are the result of an attempt at repair and regeneration, which is "...doomed to failure in virtually all instances." (Chiroff 1977:57).

Diagnosis of osteoarthritis in skeletal collections is based on the pattern of osteophytic remodeling, porosity, grooving, and eburnation of the bone, subchondral cysts and sclerosis (Steinbock 1976, Cassidy 1979, Cockburn _et al_. 1979, Ortner and Putschar 1981). The latter two criteria must of necessity be diagnosed radiographically unless destructive methods of analysis are utilized.

Articular Cartilage

The working hypothesis utilized by most researchers in the field of osteoarthritis as of 1979 (Howell _et al._) considers a final common pathway which results in the biological changes within the joint capsule. The focus of this hypothesis is that injury to the chondrocyte elaborates the reactions of the enzymes which results in the breakdown of the proteoglycans.

It is believed by the majority of researchers that the earliest evidence of degenerative joint disease is the loss of the surface layer of articular cartilage cells and the resulting fibrillation of the articular cartilage originating in the tangential layer and proceeding through the deeper layers as the disease progresses; fissures may extend as deep as the calcified zone (Lee et al. 1974, Bollet 1969).

Vignon et al. (1974) examined both badly worn cartilage and intact cartilage from femoral heads recovered at surgery for replacement arthroplasty for osteoarthritis. The grossly normal cartilage displayed histological changes in cellular shrinkage and the fibrillar appearance of the matrix. Early osteoarthritic cartilage suggests cellular alteration throughout the cartilage depth. His conclusions suggest that decreased matrix synthesis and necrosis of cells contribute to the degeneration of cartilage.

Studies initiated by Inoue (1981) indicate that the initial changes occur around the tidemark and adjacent osteochondral junction. The primary event appears to be the loss of proteoglycans (Bullough 1979, Sapolsky and Howell 1976, Weiss 1979). There is a relative decrease in the concentration of proteoglycans and a diminution of chondroitin sulfate A and keratan sulfate, and an increase of chondroitin sulfate C (chondroitin-4 sulfate) (Soren 1982, Mankin 1982). Thompson and Oegema (1979) found a progressive loss of glycosaminoglycans per cell as the histological grade of osteoarthritis increased.

In advanced osteoarthritis, the decreased concentration of proteoglycans is evident even in the deeper zones where there is significant destruction of cartilage matrix (Shitama et al. 1981). There appears to be no change in collagen content (Mankin and Lippiello 1970) but an increase in the number of cells (Mankin 1974b), and a significant increase in collagen synthesis (Lippiello et al 1977). The collagen fibers become less organized (Lee et al. 1974). Minns et al. (1977) found torn collagen bundles in all twenty-one osteoarthritic specimens in a topographical study of diseased articular surfaces. Pelletier et al. (1983) suggest that a possible mechanism for the loss of collagen is the increased digestion of collagen in tissue homogenates and that the source of the collagen-digesting enzyme may be the chondrocytes. These autolytic lysosomal enzymes probably may be held responsible for the destruction of the cartilage (Mankin 1976), the concentration of these enzymes increases in proportion to the severity of the disease. For a comprehensive discussion of the degradative enzymes see Howell (1975) and Harris (1978).

Neutral proteoglycanase is also suggested as a principle agent in the degradation of cartilage (Howell et al. 1976).

Mankin et al. (1971) found a higher concentration of hexosamine and DNA, and an increased rate of incorporation of $^{35}SO_4$.

Diseased articular cartilage has an increased water content which is one of the earliest changes (Muir 1978) and the most consistent (Cooke <u>et al.</u> 1980). The greater hydration may be a factor in the loss of elasticity and the decrease in efficiency of lubrication (Weiss 1979), and may lead to metabolic change (Muir 1978).

Arnoldi and Reimann (1979) found that in femoral heads the degree of cartilage deterioration varied between the different areas within the same surface. More severe changes were found within the weight-bearing surfaces than on the non-weight-bearing ones. The results of Mitrovic <u>et al</u>. (1981) support the hypothesis that chondrocytes are matrix producing cells in coxarthrosis.

<u>Synovial Fluid</u>

There is no agreement as to whether the viscosity of synovial fluid in osteoarthritic patients is higher or lower than in control groups (Sokoloff 1969, Ilardi and Sokoloff 1981). There is evidence of a reduction in hyaluronic acid concentration (Lee <u>et al</u>. 1974). Barnett (1956) concluded that in rabbits, wear and tear of articular cartilage can be caused by reducing the viscosity of synovial fluid. Ilardi and Sokoloff (1981) however feel that the abrading of the articular cartilage is perhaps the result of an associated synovitis and not the result of the reduction in viscosity.

Cartilage fragments are often found in synovial fluid from affected patients (Bollet 1969, Schumacher 1975). Plasma proteins increase in synovial fluid when the synovium is inflamed (Bullough 1979).

Synovial Membrane

The histopathological changes in the synovial tissue in osteoarthritis patients are similar to those of post-traumatic synovitis, manifesting a small range of changes (Soren et al. 1976a, 1976b). The cells forming a cover of varying thickness, two to four rows of cells, are mostly monomorphic in osteoarthritis, often round or cuboid with extended filopedia toward the surface. The infiltrates are mostly lymphocytes. Dense fibrosis usually characterizes the subsynovial tissue. The same authors (1978) found inflammatory reactions more common in osteoarthritis than in post-traumatic synovitis. Two alterations in the tissue, inflammatory reaction and sclerosis often overlapped.

Synovitis results from injury due to the presence of cartilage cell and bone cell fragments in the joint space which activates the phagocytic system (Fritz et al. 1982). Histochemical studies indicate that only a small percent of synovial cells contain lysozyme. Amyloid deposits have been found negatively associated with inflammatory cell infiltration and positively associated with pyrophosphate deposits and chondroid metaplasia in osteoarthritis. In addition no correlation was found between the degree of severity of osteoarthritis and amyloid deposits (Ladefoged 1982, Ladefoged et al. 1982, Ladefoged 1983).

Synovium from osteoarthritic joints can produce collagenase; its presence is determined by "...the degree of proliferation of synovial cells and the vascularity of the proliferative response." (Harris 1978:250). This degradative enzyme is found in lesser amounts in degenerative joint disease than is found in rheumatoid arthritis.

Bone

Bone is a dynamic material, constantly undergoing remodeling as older or injured bone is removed and replaced by newly mineralized bone. Bone renewal follows a predictable sequence: activation of precursor cells, deossification or resorption by osteoclasts, and formation of new bone by osteoblasts. This sequence takes about ninety days (Duncan 1983).

The earliest bone change in osteoarthritis is often an encroachment by mineralized cartilage into the cartilage at the tidemark; this shows up as a narrowed joint space on x-ray. Another early change may be in bone density of the subchondral bone and trabeculae which have undergone microfracture and callus formation resulting in less resorption or more formation of mineralized bone to produce sclerotic bone (Mankin 1976). Recent studies indicate that, although degenerative joint disease is age related, a large proportion of non-arthritic females retained normal trabecular structure through the eighth decade (Dequeker et al. 1977).

Osteoarthritic bone often displays microfractures, and there appears to be a continuous process of these microfractures and their repair (Hughes 1979). Cameron and Fornasier (1975) however found no difference in the number of stress fractures between normal femoral heads and those exhibiting other symptoms of early degenerative joint disease.

Osteoarthritic bone has a tendency to be osteosclerotic; Peltonen et al. (1981) found 71.7% of subchondral bone in osteoarthritic cases to be sclerotic. The sclerotic bone is focal, the severity varying with the degree of damage to the adjacent hyaline cartilage (Havdrup et al. 1976).

In later stages, the sclerosis extends a few millimeters below the joint surface before becoming normal trabeculae. Christensen et al. (1982) found a greatly increased mass of bone within the weight bearing condyle of the knee. The less loaded condyle possessed a quantity of bone mass equal to that of the corresponding mass in a normal knee; there was no osteoporosis evident.

In the last stages of the disease, the subchondral plate becomes thickened and polished, rather like ivory, and is designated as eburnated bone. Both corrosive and abrasive wear are agents in producing eburnation (Cameron and MacNab 1975b). The superficial bone is often grooved and usually pitted. There are two types of marrow under areas of sclerosis and eburnation: arthosic with areas of stasis and edema, and necrotic with stasis, edema, and diffuse necrosis (Ficat and Arlet 1975.)

Bone cysts, round or pyriform areas of translucency within the subchondral bone, are common in advanced osteoarthritis (Landells 1953, Collins 1953, Rhaney and Lamb, 1955). They are found most often within the femoral head. Their aetiology has been the subject of some controversy. Early studies indicated that they were caused by the intrusion of synovial fluid into the bone (Landells 1953, Bland 1983), or that the defects were filled with synovial fluid after bone necrosis occurred caused by the violent impact of the opposing articular surfaces after the articular cartilage had deteriorated

(Rhaney and Lamb 1955). Johnson (1959:1229) wrote that bone cysts originate as "...dysplastic foci of bone marrow which proliferate...." Milgram (1983) in a study of 535 femoral heads, found that the cysts consisted of proliferating myxomatous cells, and that the cyst lining produces the tissue and fluid found within the cyst. He found no evidence to suggest that any joint fluids had intruded into the cysts. He states that a majority of the femoral heads in his study contained bone cysts while Trueta (1968) found one or more cysts in each femoral head removed at operation.

<u>Osteophytes</u>

A distinctive and characteristic feature of osteoarthritis is the development of osteophytes (Jeffery 1975). The earliest visible osteophytes originate along the periphery of the joint between the articular cartilage and the synovial membrane (Trueta 1968). Growth is accomplished by a form of enchondral ossification. These bony extrusions are composed of very thin new cortical bone and trabeculae with an active marrow; this new bone is highly vascularized (Duncan 1983, Trueta 1968).

Osteophytes develop most often in bone with good mineral mass, osteoporosis and osteoarthritis are rarely seen together (Duncan 1983, Dequeker <u>et al.</u> 1983). The superficial layer of the osteophyte is composed of differentiating mesenchymal tissue with an abundance of cells, and is usually covered with cartilage (Mankin 1976). Deeper layers contain active proliferating and differentiated cells (Jeffery 1975, Cuccurullo and Croce 1980).

The formation of osteophytes increases the surface area subjected to load bearing in an attempt to equalize the distribution of forces (Cuccurullo and Croce 1980). Ehrlich (1979) hypothesized that osteophytes act as splints to reduce the range of motion. Trueta (1968) postulated that malnutrition, caused by a lack of pressure on degenerating cartilage, resulted in an osteophyte attempting to revitalize the diseased cartilage.

It is felt by some that osteophytes can occur independently of osteoarthritis and that their distribution should not be used to determine the severity of the disease (Johnson 1959, Danielsson and Hernborg 1970, Duncan 1979).

Aetiology of Osteoarthritis

Arthritis is the most common malady to afflict the human species and osteoarthritis is the most common of all the arthritides (Huskisson 1979). Reflecting this high morbidity are the more than numerous appellations which have been utilized to describe this disease. Tarnopolsky

(1950) lists fifty-three names. These reflect the thought of the scientific world from 1835-1950 concerning the aetiology of osteoarthritis.

There are currently several schools of thought concerning the primary aetiological factor in osteoarthritis. In fact, some researchers now consider this disease to be "...a group of disorders that share a common end stage." (Gardner 1980:384). Although there is general agreement on a morphological and biochemical sequence of events or a final common pathway which manifests itself in this disease (Howell et al. 1979), there is still a need to unravel the complex network to determine the primary aetiological factor. In the last few years several factors have been suggested to be primary by some researchers.

The most common and obvious explanation for osteoarthritis has been the repetitive use or overuse of a joint (Gardner 1980). Duncan (1979) feels that the microtrauma which results from excessive use is probably the most important factor in the aetiology of the disease. Peyron (1979) agrees that overuse of the joint is the vital factor. Cobb (1971) feels that there is striking evidence that heavy work is a contributing factor; however he also feels that there must be other factors involved.

One aetiological model is the impact loading hypothesis which states that repetitive impulse loading may produce degenerative changes within the joint. These changes include tensile fatigue of the cartilage and trabecular microfractures in the subchondral bone. Those activities of an impulsive nature include running, climbing, walking, and rising from a chair (Radin et al. 1972, Radin et al. 1976). Indeed this last activity has been shown in recent work to have the highest peak focal pressure of the listed activities (Hodge et al. 1986).

Radin and his co-authors utilized three models: an in vitro model with bovine hooves, and two in vivo models, one using guinea pigs and one utilizing rabbits. In the first, repetitive impulse loading and oscillation caused cartilage breakdown rapidly (Radin and Paul 1971). In the latter two studies a difference in bone stiffness was detected in three days with the guinea pigs and six days with the rabbits (Simon et al. 1972, Radin et al. 1973). Currey (1984) feels that Radin's results indicate that cartilage does not have a very important function in reducing the impact of impulse loading.

Kusakabe (1977) suggests that differences in cyclical loading may produce differences in remodeling of trabecular subchondral bone that display deformation patterns of the femoral head that are dissimilar.

The fatigue failure of cartilage has been expounded as an explanation for the pathogenesis of this disease (Freeman 1975, Schofield and Weightman 1978). The latter authors hypothesize that among numerous aetiologies some cases of osteoarthritis may be due to this failure and that this is clearly age-related. Their work indicated that cartilage tissue from twenty year olds would not fail after the application of 100 million cycles at a stress of 5 MN/m^2. Cartilage from fifty year olds failed after the stress of 10 million cycles.

Stephens et al. (1979) suggest that a lack of protease inhibitor synthesis by the chondrocytes is a possible hypothesis for the initial lesion in osteoarthritis. This hypothesis is based upon research other than their own.

The role which heredity may play in the development of this disease has many possibilities: a genetic predisposition to the development of osteoarthritis (Cobb 1971), an hereditary abnormality of the joint (Harris et al. 1979) either a joint deformity (Calandriello 1963, Bird 1977, Cooperman et al. 1983) or an inherited metabolic disorder (Bunim 1963) which results in premature joint damage (Doherty et al. 1983). Although "...generalized osteoarthritis does not follow simple Mendelian inheritance..."(Harper and Nuki 1980:185), there may well be a genetic component in the susceptibility of joints to osteoarthritis. However as Cobb (1971) reminds us, property, habits, and occupational choice are often handed down through the family as well as genes, and these culturally induced mores can be potent factors in the development of disease.

Inflammation

The hypothesis that osteoarthritis has no inflammatory component is emphasized by the use of "osteoarthrosis" and "degenerative joint disease" among many in the medical and anthropological community. It has now been accepted by most researchers that inflammation is a component in osteoarthritis (Schumacher 1978, Huskisson et al. 1979, Dieppe et al. 1980). In fact, inflammation of the synovium is present more than fifty per cent of the time in osteoarthritic cases (Altman and Gray 1985). Ehrlich entertains the notion that osteoarthritis may be secondary to inflammation (1978, 1979). He suggests that inflammation is the cause and also the result of osteoarthritis and that the two types can be differentiated: immune deposits in the cartilage and synovial membrane indicate causal inflammation while cartilaginous debris contribute to the resultant inflammation.

Soren (1982) suggests that "chondrosarthritis" is a more accurate term since his hypothesis is that the pathogenesis is the degeneration of articular cartilage and the consistent inflammatory changes of the synovial membrane involve the entire joint. His studies show that "...all tissue changes regarded as criteria of inflammation also occurred in osteoarthritis...."(1982:3).

Crystal induced synovitis is a possible contributing factor in inflammation in osteoarthritis (Dieppe 1978). Mixed crystal deposition is often found in articular cartilage (Boivin and Lagier 1983), hydroxyapatite crystals in synovial fluid (Dieppe et al. 1978, Doyle et al. 1977, Doyle 1982) and cholesterol crystals in synovial fluids (Fam et al. 1981). The presence of calcium phosphate crystals in synovial fluid and inflammation are often both found in sufferers of osteoarthritis (Doyle 1982). Whether the degenerative process results from the crystal deposit or causes it is still being examined (Schumacher 1978).

Joints affected by calcium pyrophosphate dihydrate (CPPD) crystal deposits are subject to more osteoarthritic lesions and more severe ones than joints without CPPD (Mitrovic 1983).

Ali and Griffiths (1983) suggest that a calcification abnormality in the osteoarthritic joint may be one aetiological factor. Three different types of calcium phosphate crystals, quite distinct from calcium pyrophosphate crystals dihydrate (CPPD) are found in separate zones of diseased articular cartilage specimens. These apatite crystals are present in normal cartilage near the tidemark, but in diseased tissue there is an increase in their numbers and their distribution throughout the cartilage.

Tissue calcification is another possible intra-articular inflammatory agent. Calcification of cartilage, synovium, or of the capsule was discovered in all of Doyle's osteoarthritic patients (1982); 75% of articular cartilage and 68% of the synovium and capsule were affected. He considered this part of the disease process and not a concomitant of the aging process.

There are those who feel that osteoarthritis of the hip is always secondary to an abnormality of the joint (Solomon 1976). W. H. Harris is quoted in Lewin (1986) to the effect that 90% of hip osteoarthritis is due to a structural abnormality. This apparently exaggerates the focal pressure and assists in cartilage deterioration.

Intensive research in the field of genetics and its role in osteoarthritis must be undertaken before its importance can be evaluated and a definitive statement can be made. For the purpose of this paper, osteoarthritis of the hip will be treated as an idiopathic or primary condition.

The consistency with which the pattern of involvement between the sexes varies requires that the role of sex be considered within the cultural context. This matter will be discussed in Chapters Five through Nine in conjunction with the results and conclusions.

At one time obesity was considered to be a contributing factor to the development of osteoarthritis, however in a study of twenty-five grossly obese males, Goldin et al. (1976), state that their results refute that hypothesis. They did find that obese individuals have a predisposition to traumatic injury to the knee.

Among the non-human mammals which have been utilized in experiments dealing with osteoarthritis are dogs, monkeys, guinea pigs, and rabbits. Saaf (1950) investigated the reaction of cartilage in guinea pigs to the heavy use of the joint. Barnett (1956) found a decrease in the viscosity of synovial fluid with increased wear and tear in the joints of rabbits. Salter and Field (1960) found a necrosis of cartilage in relation to the lack of nutrition due to contact pressure in monkey joints. Muir (1978) utilized dogs to determine that the earliest detectable change in cartilage was the decrease in hydration leading to metabolic changes. Walton (1977) suggests that an abnormality in the distribution of the transmitted mechanical load is the primary aetiological factor in osteoarthritic lesions in the STR/ORT mouse.

CHAPTER III

DISCUSSION OF SAMPLE

Averbuch

The Averbuch site (40DV60) is located in the Bordeaux area of north Davidson County, nine kilometers west of Nashville, Tennessee (Reed 1978). Reed (1984a) lists the geographical co-ordinates as 36 13' 12" north latitude and 86 50' 59" west longitude (Figure 3.1). Geographically the site lies within the transitional zone between the Nashville Basin and the Highland Rim, specifically on the southern grade of a hill east of Drake Branch, a small tributary of the Cumberland River. A second tributary of the Cumberland, White Creek, is located a little over two kilometers from the site (Berryman 1981).

This area is included in the mixed mesic or tulip-oak forest and includes Cumberland fauna (Shelford 1963). The mixed deciduous forest provides subsistence for an abundance of animals easily utilized by the human population. White-tailed deer were especially abundant in the days of the early settlers in Tennessee and by extrapolation during the domicile of the Indian. Turkeys were also an important component of the biota as were numerous species of small mammals.

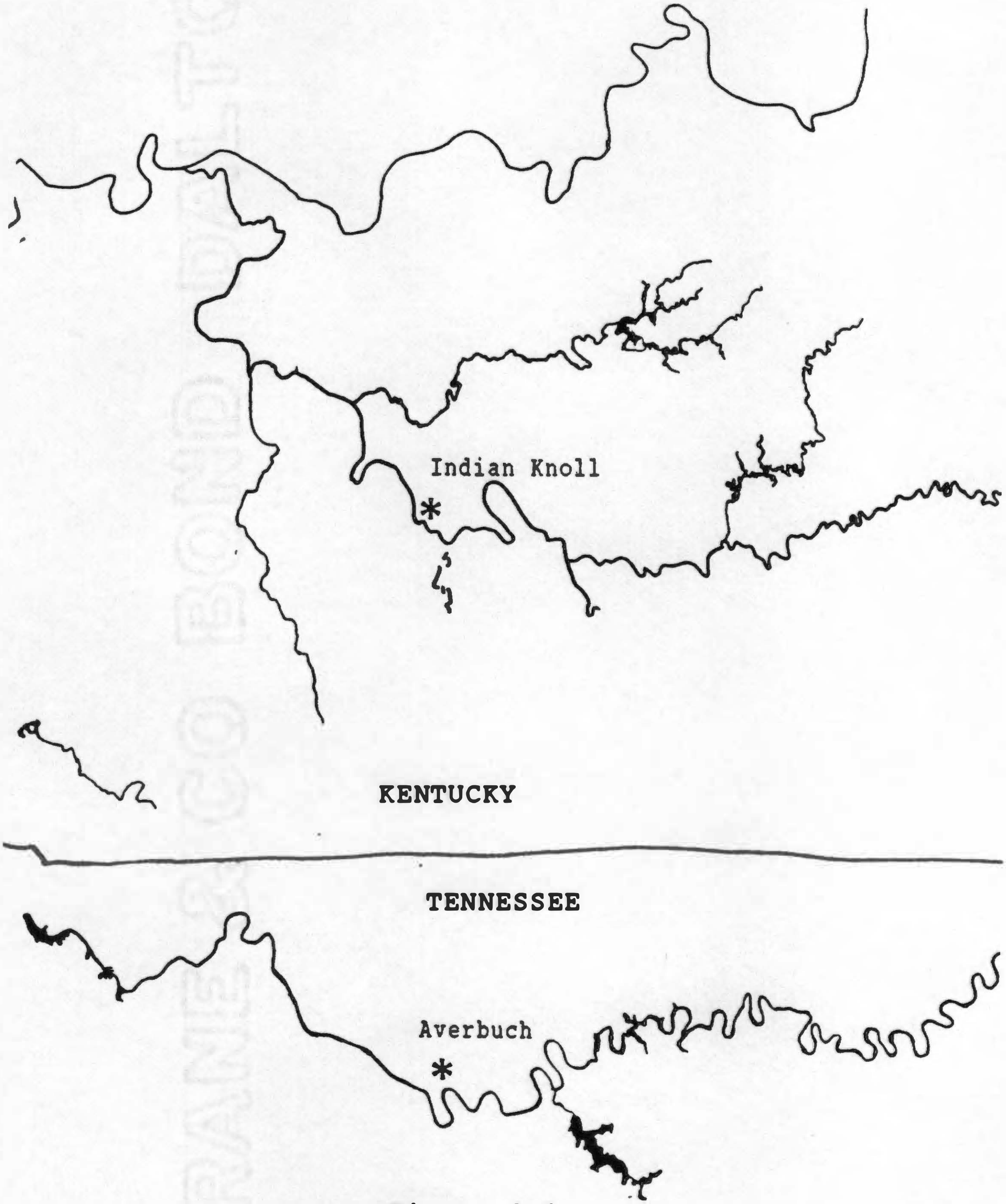

Figure 3.1

Map of Kentucky and Tennessee Showing Sites

Excavation of the Averbuch site was begun in 1975 by coinvestigaters Patricia Coats and Donald P. Rapp after the site was reported to the Tennessee Division of Archaeology and assessed by Joseph Benthall, the Director of the Division of Archaeology. These test excavations were executed with the assistance of volunteers from the Tennessee Archaeological Society, the Volunteer State Archaeological Society, and the students of anthropology classes at McGavock High School (Rapp 1976). The discovery of forty-nine stone box graves and the remains of a village resulted in the Averbuch site being listed in the National Register of Historic Places.

Further excavations were conducted beginning in September 1977 by the Department of Anthropology of the University of Tennessee under contract to the Interagency Archaeological Service of Atlanta. The two phases of this investigation, September 26, 1977-December 15, 1977 and March 20, 1978-July 1978, were conducted by Dr. William M. Bass and Dr. Walter E. Klippel, coinvestigaters, with Hugh Berryman and Ann Reed serving as field supervisors (Reed 1984b).

The University of Tennessee excavations resulted in the recovery of skeletal material of 887 individuals from 645 graves, the majority of which were limited to three distinct cemeteries with thirty-five individuals associated with structures. Berryman (1984) estimates that 409 individuals were not recovered, bringing the estimated total skeletal series to 1296 individuals.

The Averbuch site, which consists of a village surrounded by a stockade and three cemeteries, falls into the Middle Cumberland Culture stage in Tennessee (Berryman 1981, Ferguson 1972). This Middle Mississippian Phase was characterized by a subsistence based on agriculture and a burial complex manifested by stone box graves. Clayton (1880:16) states that when the earliest European settlers arrived "...that hunters and pioneers trod over vast cemeteries of an extinct race." These cemeteries consisted of carefully constructed stone graves, pits lined with natural slabs of stone with flat stones along the sides and at the head and foot. The top of the coffin was covered with one or more flat stones (Jones 1869, Bushnell 1920, Dowd 1972). The cemeteries were indeed vast; Thruston (1897) discusses an area containing over 3000 graves five miles south of Nashville. Robertson (1878) and Troost (1845) discuss the parameters of other sites, and that the cemeteries "...are found everywhere around Nashville..." (Robertson 1878). Many of these graves were excavated in the 19th century (Dunning 1871, Clark 1878, Putnam 1878) and some skeletons subjected to measurement (Carr 1878).

When the first Europeans arrived in middle Tennessee, this area

> had not a single permanent inhabitant except for the beasts of the forest but it had been inhabited many centuries before by a numerous population (Haywood 1823:108-109).

Hunting camps, utilized by the Shawnee tribes of Kentucky, were the only indication of the presence of living Indians, and in the first decade of the eighteenth century, even this remnant population was removed by the combined forces of the Cherokee and Chickasaw tribes (Ramsey 1853).

The subsistence base of the Middle Cumberland Culture is presumed to be that of an horticultural or agricultural tradition. The Arnold Site contained remains of corncobs and beans (Ferguson 1972), presupposing a knowledge and utilization of agriculture. The Averbuch Site also contained remains of corn (Crites 1984). Gourd effigy bowls, sometimes with blossoms and stems, are found in Middle Cumberland sites (Clark 1878, Ferguson 1972).

Stone hoes, found in numerous sites representative of the Middle Cumberland, are described by Glenn (1910:270). This implement

> is the long, broad, flat, sharp-pointed stone hoe, an implement supposed to be fastened to a stick or handle and used for cultivating maize.... They exhibit considerable variety in shape, and some are of unusually large size, being twelve to fourteen inches in length and six or eight inches wide.

Similar implements were found during the excavation at Averbuch (Kline 1984).

Indian Knoll

The Indian Knoll site (Oh-2) is a shell midden (mound) along the southern edge of Ohio County, Kentucky along the northeastern bank of Green River, one half mile upstream from Paradise, Kentucky which is across the river on the southwestern bank. Geographically the site is along the southeast border of the Illinois Basin. Outcroppings of sandstone along the rolling hills peak at 200 feet above the fertile bottom lands (Webb 1946) (Figure 3.1).

A mixed mesophytic or tulip-oak forest dominated this region prior to European settlement and supported a wide range of fauna including an abundant supply of white-tailed deer, turkeys and other small mammals (Shelford 1963). The wood rat, although normally occurring in the oak-chestnut forest at slightly higher elevations, also frequented the cliffs above the Green River.

Indian Knoll was originally excavated in 1915 by C. B. Moore for the Academy of Natural Sciences of Philadelphia. His crew of eight devoted 22.5 days to the site and recovered 298 human skeletons (Moore 1916). He sent 66 skulls and a few other bones to the United States

National Museum as a gift where they are currently housed (Moore 1916, Snow 1948).

A second and more extensive excavation was undertaken by Marion H. Baugh and a crew of Works Progress Administration (WPA) laborers from 1939-1941 (Webb 1946). There was concern that with 298 skeletons already recovered from the site, there would be very little undisturbed midden to present an adequate sample for further study of Indian Knoll. To the excavators' gratification, an additional 880 burials were recovered, and, even so, did not exhaust the site since lack of funding required termination of the excavation before it was completed (Snow 1948). Robbins (1977) in a later analysis of the archaeological data from Indian Knoll asserts that only 60--70 % of the site was excavated.

This multiple component site was apparently occupied for at least 500 years encompassing the years 3352$\pm$30 to 2013$\pm$350 B.C. and leading from the Archaic into the Mississippian culture periods (Snow 1948, Robbins 1977, Lewis and Kneberg 1959, Libby 1955).

The Archaic lifestyle was a foraging and totally exploitive manner of subsistence (Jennings 1968). In this migratory hunting and gathering stage, dependence was on smaller fauna than in the previous Lithic period (Willey and Phillips 1958). Mussels apparently provided a staple food source although there are divergent opinions as to their relative importance in the Indian Knoller's diet (Cook 1946, Meighan 1970, Cassidy 1972, Parmalee and Klippel 1974, Kelley 1980, Parmalee 1985). A relatively few deer bones were found in conjunction with the Indian Knoll site which led to speculation concerning whether the site was a permanent habitation or only used seasonally (Cassidy 1972). The utilization of plant food may well have been of primary importance in this period of the Archaic stage (Fowler 1971).

The shell mound at Indian Knoll is located on a natural levee that was almost water-locked during aboriginal times by the Green River and Pond Run. The enclosed area contained about 700 acres of fairly level plain, a perfect site for a village whose inhabitants exploited a hunting and fishing subsistence. The fertile bottom land adjoining the river gradually changes to rolling hills covered with a variety of conifers and hardwood forests which provided cover for a rich range of flora and fauna (Snow 1948).

The site itself is a deep shell midden with a midden deposition depth as much as eight feet on the river side of the site and about five feet along the second bank (Webb 1946). No stratification is present; there is a continuous deposit of village debris and shell. No evidence of permanent habitation structures was present, although remains of postholes were scattered around areas of fired clay; presumably some sort of windbreak had been used. Apparently thin layers of clean clay had been laid across midden creating living floors on which the fires had been laid. Numerous fire cracked rocks, such as would have been used as boiling stones were found among the debris (Webb 1946).

CHAPTER IV

METHOD AND METHODOLOGY

Method of Analysis

The analysis of degenerative joint disease in skeletal series has been undertaken previously using ordinal scoring systems (Jurmain 1975, Merbs 1983, Kilgore 1984). A similar rating system utilizing ordinal categories was devised as the standardized procedure accepted by the Council for International Organizations of Medical Sciences in the radiological determination of the rheumatic diseases and published in the *Atlas of Standard Radiographs of Arthritis* (1963). The diagnosis of degenerative joint disease in living patients should be by radiological evidence as determined utilizing the *Atlas* (Laine 1968). Since the degree of narrowing of the joint space is impossible to determine on dry bone, visual and microscopic examination replaces radiographic examination of skeletal material. Cassidy (1979) and Cockburn *et al.* (1979) both briefly discuss the diagnosis of osteoarthritis in dry bones.

This study utilizes an ordinal system modified from Jurmain (1975), and corresponding closely with that described in the *Atlas of Standard Radiographs of Arthritis* (1963). Forty-five discrete areas of articulating bone surface from each side of the body were examined and scored 0-4 according to the degree of change. Appendix B contains a description of each variable and the method of scoring.

It must be realized that although degenerative joint disease is a progressively destructive disease, data gathered must be on an ordinal scale rather than an interval one. While a score of 2 shows more disruption to the articular surface than score of 1, it is not necessarily twice as disrupted as 1; the intervals are not equally spaced.

The possibility of intraobserver error was checked with the samples from each skeletal series. After fifty specimens had been examined and scored from each sample, the first ten individuals examined were rescored and the scores compared with the original scores. Less than two percent of the rescores were different and all were between the none and slight categories. The data from each population are compared by variable. The variables from each joint are pooled for the purpose of comparing the populations by bone totals within each joint and by each joint. The ages were pooled into a variable termed agegroup denoting a ten year span for the twenties and thirties and perhaps more than that occasionally in the overforties. To further separate the sample into forties and fifties would have created samples too small to have statistical reliability. The pattern of involvement is examined, and all variables are compared by agegroups, side and sex.

Statistical Analysis

The application of statistical analysis to anthropological studies is rapidly becoming the most acceptable method of interpreting data. W. W. Howells, author of Cranial Variation in Man (1973), was the pioneer in the utilization of multivariate analysis methodology in anthropology, and was the inspiration for numerous researchers since that time.

Ordinal data, such as those collected for this study, require order techniques of analysis which are usually regarded as nonparametric methods. These techniques essentially test the hypothesis of identical population distribution (Hays 1981). The statistical test utilized in this comparative study is the Mann-Whitney, which is one of the most powerful nonparametric techniques. It compares well with the t-test and, on occasion, is even superior to it.

The statistical analysis for this study of degenerative joint disease was run on the IBM computer using the NPAR1WAY program developed by SAS Institute Inc

(1985). This is a nonparametric procedure for testing the null hypothesis that the distribution of a variable has the same location parameter between two groups. A Z score was computed and a probability derived from that. The FREQUENCY program from SAS was also utilized in the analysis of the bone and joint totals; it provided a Chi square approximate test.

All computer programs were run through the Computer Center, University of Tennessee, Knoxville, Tennessee.

The Sample

The skeletal material from Indian Knoll is curated at the University of Kentucky's Vine Street Anthropological Laboratory in Lexington, Kentucky. Of the 1234 individuals Snow (1948) stated had been excavated from the site, a sample of 199 adults was determined to be acceptable for this study. The remains of 91 females and 108 males were determined to be complete enough for this investigation.

Snow (1948) aged and sexed the skeletal series originally in 1948, and the ages were reassessed in 1959 (Johnston and Snow 1961). In addition, other researchers; i.e. Cassidy (1972) and Kelley (1980) have reassessed the individual ages. For this analysis of osteoarthritis, the age and sex evaluations of Johnston and Snow are used. A sample consisting of the twenty-five adults with the lowest burial numbers was selected and examined by this investigator using standard anthropological techniques (McKern and Stewart 1957, Krogman 1962, Acsadi and Nemeskeri 1970, Bass 1971, Stewart 1979, Suchey 1979); there were no appreciable differences.

This skeletal series is attractive for study due to its size and relative completeness. As a consequence numerous publications are available concerning the results of previous investigations which utilize data from this population (Leigh 1925, Cassidy 1972, Perzigian 1973, Ruff 1980).

The Averbuch human skeletal material is housed and curated at the Anthropology Annex, University of Tennessee, Knoxville, Tennessee under the direction of Dr. William M. Bass and Dr. P. Willey. The age and sex of each individual were determined by Hugh Berryman (1981) utilizing standard anthropological techniques, and these determinations were utilized in this study. A sample consisting of the twenty-five adults with the lowest burial numbers was examined by this investigator utilizing the same anthropological techniques (McKern and Stewart 1957, Krogman 1962, Acsadi and Nemeskeri 1970, Bass 1971, Stewart 1979, Suchey 1979); no appreciable differences were found.

The original intent was to include all adults above the age of nineteen years in this assessment of degenerative joint disease; however, due to the fragmentary nature of the material and poor preservation of the articular bone surfaces, a final sample of 196 individuals was accepted; this includes 95 females and 101 males.

The criteria for an individual skeleton to be included in the sample were identical for each population; an age estimate of nineteen years or above, a complete enough individual for a sex determination, and a minimum of three joints complete enough to be scored.

Although this is a fairly recently excavated skeletal series, several investigations have centered around data collected from this population (Berryman 1981, Jablonski 1984, Guagliardo 1982, Eisenberg 1986). The primary data and original analyses are available in Averbuch. A Late Mississippian Manifestation in the Nashville Basin (Klippel and Bass 1984).

CHAPTER V

THE KNEE JOINT

Degenerative Changes

The knee is one of the more complex joints in the body; it is composed of three bones; femur, patella, and tibia all of which are encased by a thick, fibrous capsule lined with the synovial membrane. Flexion and extension are the primary movements of the knee with a limited degree of lateral and medial rotation allowed by the collateral ligaments (Shipman et al. 1985).

The change of one parameter within the joint requires the counterbalance of one other or several others. When compensation can no longer be effected, osteoarthritis ensues (Maquet and Pelzer 1977). Kellgren (1961:1) defines osteoarthritis "...as an expression of a joint's inadequacy to meet the mechanical stress placed upon it...."

The progression of the degenerative changes in osteoarthritis of the knee is similar to that of any synovial joint; cartilage destruction with flaking and fibrillation, marginal osteophytes, denudation of bone, and eburnation of the bone (Jacobsen 1977). The presence of osteophytes alone should not be utilized as a diagnostic tool (Danielsson and Hernborg 1970, Nilsson et al. 1982).

Several investigations have been implemented to discover what factors are associated with arthritic changes in the knee. Gupta et al. (1979) found age, body weight, and patella alta significantly associated in an autopsy study in India. There is a strong association between anterior femoral erosion and osteoarthritis of the knee (Rose and Cockshott 1982) and Fenelon and Cockshott (1982) found it to be highly significant statistically ($p<0.001$). Popliteal cysts have a definite correlation with the early onset of osteoarthritis ($p<0.02$) although they are more associated with age than with osteoarthritis ($p<0.001$) (Fenelon and Cockshott 1982). There is a possibility that both femoral depression and popliteal cysts are the result of increased pressure.

There are those who have felt that chondromalacia of the patella was a precursor of osteoarthritis of the knee although in only a few individuals will it progress to osteoarthritis (Wiles et al. 1956). New methods of surgical intervention including arthroscopic surgery and the development of partial meniscectomies can help prevent post-traumatic osteoarthritis; in the past, damage to the anterior cruciate ligament was often effected (Funk 1983) producing instability of the knee leading to further deterioration of the integrity of the joint. Instability of the knee is the most important factor in the development of osteophytes in knee joints in dogs (Marshall and Olsson 1971).

Patterns of involvement of osteoarthritis vary between geographical areas (Bremner _et al._ 1968). In a comparison of radiological changes between a Jamaican sample and general populational studies undertaken in England a greater prevalence of osteoarthritis of the knee was found among the Jamaicans. Bremner _et al._ (1968) suggest that the prevalence of rough footpaths may explain the difference. Another finding was that the rate of complaint was less among the Jamaicans than among English populations for the same degree of severity. The authors suggest that radiant heat and temperature may explain the lower complaint frequency.

There appears to be no connection whatsoever between social class and osteoarthritis in the New Haven, Connecticut survey (Acheson and Collart 1975).

Prevalence of osteoarthritis of the knee is quite high among Nigerians, 39.5% of Eborg's (1985) patients were below the age of 50 years. A high degree of severe valgus deformity is common both among the osteoarthritis patients and among children suggesting a possible relationship there. An increased quantity of woven bone at the loaded tibial condyle in valgus and varus knees suggests an early phase of development in the arthritic knee (Hvid and Hansen 1986).

An epidemiological study in Sweden by Bjelle (1982) showed regional differences in the prevalence of osteoarthritis with the higher rates in the farming and forestry areas.

The symptoms of osteoarthritis of the knee include crepitus, pain, morning stiffness, swelling, decreased range of motion, instability, and eventually deformity (Gresham and Rathey 1975, Fujikawa et al. 1983). However, symptoms in the knee joint do not necessarily indicate the development of either rheumatoid arthritis or osteoarthritis, and no single symptom occurs in all individuals with radiological changes due to osteoarthritis (Gresham and Rathey 1975). Lawrence et al. (1966) in an investigation of a random sample of two populations in Northern England realized a 23% complaint rate in males and a 20% complaint rate in females none of whom presented radiological evidence of either arthritide. There was an apparent association between pain and obesity with the individuals who had osteoarthritis but none with those with no radiological evidence of disease. Conversely, 70% of radiologically diagnosed osteoarthritic knees in veteran soccer players in Switzerland were asymptomatic (Chantraine 1985).

The loss of bone mass in patients with osteoarthritis appears to be a result of inactivity rather than a direct result of the degenerative changes (Hancock et al. 1978).

Comparison of Original Variables

Sixteen discrete areas of articular surfaces on the three bones were scored for porosity, pitting, osteophytic exuberance, and eburnation; seven on the tibia, six on the femur, and three on the patella. The areas are:

Proximal Tibia

a. TLCT - Lateral condylar tubercle

b. TMCT - Medial condylar tubercle

c. TPCL - Insertion of posterior cruciate ligament

d. TLLB - Marginal lipping, lateral border

e. TLMB - Marginal lipping, medial border

f. TLAS - Lateral articular surface

g. TMAS - Medial articular surface

Distal Femur

a. FTL - Transverse lipping

b. FMCL - Marginal condylar lipping

c. FNL - Intercondylar notch lipping

d. FLCS - Lateral condylar surface

e. FMCS - Medial condylar surface

f. FPS - Patellar surface

Patella

a. PDL - Dorsal lipping

b. PVL - Ventral lipping

c. PAS - Articular surface

See Appendix B for illustrations and method of scoring.

Because osteoarthritis is age-related it is useful to control for that variable when comparing samples of more than one population. The samples examined in this project were divided into three categories of age; twenties, thirties, and overforties. Each will be addressed in turn as will the combined sample.

In the agegroup twenties, Table 5.1, Averbuch has a higher mean on each variable except the femoral medial condylar surface of the female sample where Indian Knoll is higher. The mean of the tibia medial articular surface is the same for the females of each sample. There is little difference in the number of variables between the males and females which are statistically significant at the p=.001 level or better; no distinctive pattern appears. With the sexes combined, there is a tendency for the variables describing surface areas to exhibit a difference in the means at a less statistically significant level than the differences in the cruciate ligament insertion area, tubercles, or lipping variables

TABLE 5.1

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP TWENTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
TLCT	59	61	.29	.11	.0183	73	51	.44	.10	.0000	132	112	.37	.11	.0000
TMCT	60	61	.43	.13	.0002	67	51	.72	.41	.0014	127	112	.58	.26	.0000
TPCL	65	62	.22	.00	.0001	84	55	.44	.24	.0329	149	117	.34	.11	.0000
TLLB	38	56	.08	.00	.0346	58	51	.09	.00	.0584	96	107	.08	.00	.0046
TLMB	48	58	.08	.00	.0264	65	55	.14	.00	.0128	113	113	.12	.00	.0007
TLAS	66	61	1.00	.93	.2325	92	55	1.13	1.02	.0677	158	116	1.08	.97	.0144
TMAS	67	61	1.00	1.00	.9959	90	57	1.08	1.00	.0613	157	118	1.04	1.00	.1575
FTL	68	65	.24	.00	.0000	89	60	.22	.03	.0070	157	125	.23	.02	.0000
FMCL	57	64	.05	.02	.2613	66	59	.12	.00	.0322	123	123	.09	.01	.0176
FNL	73	65	.32	.09	.0014	96	60	.50	.28	.0215	169	125	.42	.18	.0001
FLCS	68	65	1.04	1.00	.4039	89	60	1.11	1.03	.0839	157	125	1.08	1.02	.0516
FMCS	70	62	1.00	1.05	.3848	94	60	1.15	1.07	.2240	164	122	1.09	1.06	.6396
FPS	72	63	1.01	1.00	.7767	96	61	1.06	1.05	.7543	168	124	1.04	1.02	.5818
PDL	49	35	.29	.00	.0006	73	40	.62	.17	.0001	122	75	.48	.09	.0000
PVL	50	35	.20	.00	.0052	72	40	.54	.05	.0000	122	75	.40	.03	.0000
PAS	50	35	.94	.94	.9650	79	40	1.06	.95	.0342	129	75	1.02	.95	.0720

which are often highly significantly different at the p=.0000 level.

This pattern which emerges in Table 5.1, depicting the Averbuch population sample exhibiting more involvement of degenerative joint disease than the comparative sample, Indian Knoll, is typical of that of the other large postcranial joints.

Examining the statistics described in Table 5.2, agegroup thirties, for the sexes separated, the Averbuch male sample has a higher mean on every variable; in the female sample Averbuch is higher on all variables except the patella articular surface where Indian Knoll is higher and the mean of the femoral patellar surface which is the same for both samples. Three areas which were statistically significant in the females in agegroup twenties are still significant in the thirties, the medial condylar tubercle, the insertion for the cruciate posterior ligament and lipping along the intercondylar notch, none of which shows a significant difference in the males.

In the thirties agegroup with the sexes combined there has been little change in the pattern of involvement with the increase of a decade. Six variables were highly statistically significant at the p=.0000 level in the twenties agegroup and the same number have the same

TABLE 5.2

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP THIRTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
TLCT	34	75	.41	.15	.0116	24	84	.38	.25	.2319	58	159	.40	.20	.0113
TMCT	29	74	.83	.26	.0000	22	80	.68	.56	.3186	51	154	.42	.76	.0000
TPCL	37	74	.46	.12	.0001	28	84	.54	.29	.0169	65	159	.49	.21	.0000
TLLB	17	75	.12	.01	.0309	14	86	.36	.05	.0189	31	161	.23	.03	.0025
TLMB	24	73	.08	.04	.4256	20	89	.20	.06	.1385	44	162	.14	.05	.1155
TLAS	35	82	1.09	1.01	.1651	31	93	1.06	1.01	.1981	66	175	1.08	1.01	.0543
TMAS	37	82	1.11	1.02	.0995	30	93	1.13	1.05	.2435	67	175	1.12	1.04	.0453
FTL	36	88	.31	.05	.0001	37	98	.49	.01	.0000	73	186	.40	.03	.0000
FMCL	33	85	.18	.06	.0406	25	97	.52	.04	.0000	58	182	.33	.05	.0000
FNL	36	88	.53	.23	.0011	37	98	.70	.52	.1845	73	186	.62	.38	.0036
FLCS	36	86	1.17	1.02	.0099	35	99	1.20	1.11	.2203	71	185	1.18	1.07	.0158
FMCS	35	86	1.23	1.03	.0008	36	98	1.39	1.06	.0000	71	184	1.31	1.05	.0000
FPS	36	85	1.00	1.00	.9940	37	100	1.11	1.08	.6101	73	185	1.05	1.04	.7072
PDL	29	39	.86	.31	.0001	32	64	1.22	.27	.0000	61	103	1.05	.28	.0000
PVL	28	39	.71	.08	.0000	32	65	1.16	.20	.0000	60	104	.95	.15	.0000
PAS	31	39	1.00	1.03	.3882	32	65	1.25	.92	.0003	63	104	1.13	.96	.0018

probability in the thirties although they are not all the identical variables. The mean of the lateral condylar tubercle of the tibia is no longer statistically significant while that of the marginal condylar lipping on the femur now is.

In Table 5.3, the overforties agegroup shows indications of fewer differences in the means of the two samples and, by inference, more similar utilization of the joint surfaces. Another interpretation of this closer relationship between the samples may be that the exigencies of age are beginning to narrow the gap.

In the male sample, of the variables which were statistically significant in the previous agegroup, the thirties, and which encompass a large enough sample to consider, only the patella lipping is still highly statistically significant between the two sample populations.

The means of the Averbuch sample are always higher unless specifically noted. The distal tibial lateral and medial surfaces exhibit a higher mean for Indian Knoll females than for those in Averbuch. The femoral lateral condylar surface, the femoral patellar surface and the patella articular surface all have means which are equal between the two samples.

With the sexes combined, there is a general

TABLE 5.3

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP OVERFORTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
TLCT	20	13	.45	.00	.0056	16	33	1.00	.27	.0002	36	46	.69	.20	.0001
TMCT	22	15	.68	.20	.0048	15	32	1.00	.41	.0057	37	47	.81	.34	.0003
TPCL	22	14	.77	.14	.0040	18	38	.78	.26	.0020	40	52	.77	.23	.0000
TLLB	11	11	.36	.09	.2819	7	33	.57	.27	.1528	18	44	.44	.23	.1072
TLMB	12	17	.25	.24	.9524	9	38	.44	.21	.0636	21	55	.33	.22	.1542
TLAS	23	17	1.22	1.24	.5993	18	39	1.44	1.21	.0494	41	56	1.32	1.21	.1206
TMAS	21	17	1.14	1.18	.6321	18	39	1.44	1.15	.0152	39	56	1.28	1.16	.1823
FTL	20	13	.40	.00	.0346	19	45	.37	.20	.0748	39	58	.38	.16	.0122
FMCL	14	13	.57	.46	.9774	13	46	.77	.28	.0571	27	59	.67	.32	.0991
FNL	21	13	.67	.31	.0469	20	46	1.20	.48	.0001	41	59	.93	.44	.0001
FLCS	22	13	1.23	1.23	.9813	21	46	1.29	1.09	.0476	43	59	1.26	1.12	.0815
FMCS	18	13	1.39	1.15	.0877	20	46	1.50	1.11	.0001	38	59	1.45	1.12	.0000
FPS	20	13	1.15	1.15	.9793	22	46	1.23	1.17	.4784	42	59	1.19	1.17	.6218
PDL	12	6	.92	.50	.2263	16	24	1.38	.46	.0019	28	30	1.18	.47	.0008
PVL	13	6	1.23	.00	.0113	18	24	1.11	.33	.0002	30	31	1.16	.27	.0000
PAS	15	6	1.00	1.00	.0000	18	24	1.22	1.04	.0812	33	30	1.12	1.03	.2063

pattern of low significant difference in the variables describing the surface areas; the exception is the medial condylar surface of the femur which exhibits a difference at the p=.0000 level, this has not changed since the thirties agegroup.

In Table 5.4 the agegroups and sides are combined in order that comparisons may be made with other studies which have not necessarily controlled for age. The problems of recovery of archaeological samples often necessitate the inclusion of all available skeletal material regardless of the preferences of scientists in the field.

In the female sample, the Averbuch means are higher on all variables except the articular surface of the patella. The surface areas exhibit less statistical differences than the other variables although the pattern is not consistent. Three surface variables are not statistically significantly different (p=.6341, p=.7420. 0=.5187).

The pattern among the males is different, only two variables, the lateral condylar surface (p=.0838) and the femoral patellar surface (p=.9745) do not display a statistical difference, the latter variable exhibits equal means between the two sample populations.

Combining the sexes, only the patellar articular

TABLE 5.4

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME WITH AGEGROUPS AND SIDES COMBINED

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
TLCL	116	149	.34	.12	.0000	117	168	.52	.21	.0000	233	317	.43	.17	.0000
TMCT	115	150	.58	.20	.0000	107	163	.75	.48	.0001	222	313	.66	.35	.0000
TPCL	127	151	.38	.07	.0000	133	177	.51	.27	.0001	260	328	.45	.18	.0000
TLLB	69	142	.13	.01	.0011	81	170	.17	.08	.0501	150	312	.15	.05	.0005
TLMB	86	148	.10	.05	.0949	96	182	.18	.07	.0111	182	330	.14	.06	.0027
TLAS	129	160	1.06	1.01	.0721	145	187	1.15	1.05	.0088	274	347	1.11	1.03	.0018
TMAS	130	160	1.05	1.03	.6341	142	189	1.14	1.06	.0101	272	349	1.10	1.05	.0274
FTL	129	166	.29	.02	.0000	152	203	.32	.06	.0000	281	369	.31	.04	.0000
FMCL	108	162	.19	.07	.0297	110	202	.31	.08	.0004	218	364	.25	.08	.0001
FNL	135	166	.44	.18	.0000	160	204	.66	.44	.0020	295	370	.56	.32	.0000
FLCS	130	164	1.10	1.03	.0584	152	205	1.14	1.08	.0838	282	369	1.12	1.06	.0118
FMCS	127	161	1.11	1.05	.0781	157	204	1.25	1.07	.0000	284	365	1.19	1.06	.0000
FPS	133	161	1.02	1.01	.7420	162	207	1.09	1.09	.9745	295	368	1.06	1.06	.8222
PDL	92	80	.54	.19	.0000	125	128	.90	.27	.0000	217	208	.75	.24	.0000
PVL	93	80	.52	.04	.0000	126	129	.79	.18	.0000	219	209	.68	.12	.0000
PAS	98	80	.97	.99	.5187	133	129	1.14	.95	.0000	231	209	1.06	.97	.0005

surface exhibits a lack of statistical significance; it displays equal means between the samples.

The pattern of consistently higher means at such a high level of statistical significance for the Averbuch sample implies that a distinctly different pattern of cultural activity was being employed by the individuals within that population. Other biocultural factors including nutrition and population stresses are undoubtedly incorporated into the specific aetiology since no one stress factor exists without an accommodation within the organism.

The original variables controlled for sex and side are compared in Table 5.5. The means of the variables are all higher in the Averbuch sample among the females with the exception of the articular surface of the patella; the difference is not statistically significant. The left side shows a higher mean for the Indian Knoll sample and the same mean for both samples on the right side.

Among the males, two variables show a higher mean for the Indian Knoll sample, the patellar surface of the femur is higher on both the left and right sides and the lateral condylar surface of the distal femur is higher on the left side.

There appears to be more difference in

TABLE 5.5

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE AND SEX, AGEGROUPS COMBINED

Variable	Left										Right									
	Females					Males					Females					Males				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
TLCT	55	76	.29	.12	.0232	55	89	.53	.18	.0000	61	73	.39	.12	.0006	62	79	.52	.24	.0024
TMCT	57	76	.56	.21	.0000	54	85	.76	.52	.0068	58	74	.60	.19	.0000	53	78	.74	.45	.0059
TPCL	61	78	.39	.10	.0002	66	93	.52	.22	.0005	66	73	.36	.04	.0000	67	84	.51	.32	.0330
TLLB	36	71	.19	.01	.0027	41	84	.22	.05	.0246	33	71	.06	.01	.1933	40	86	.13	.10	.5875
TLMB	43	74	.07	.16	.1043	50	93	.22	.05	.0160	43	74	.05	.03	.5838	46	89	.13	.09	.2489
TLAS	61	80	1.03	1.01	.5217	70	97	1.16	1.04	.0297	68	80	1.09	1.00	.0745	75	90	1.15	1.07	.1153
TMAS	62	80	1.08	1.05	.7233	69	97	1.14	1.05	.0502	68	80	1.03	1.01	.7242	73	92	1.14	1.07	.0964
FTL	66	84	.32	.02	.0000	76	104	.30	.05	.0001	63	82	.27	.02	.0000	76	99	.33	.07	.0000
FMCL	55	81	.16	.06	.1036	53	104	.34	.06	.0079	53	81	.21	.09	.1405	57	98	.28	.11	.0220
FNL	68	84	.43	.17	.0007	82	104	.62	.42	.0464	67	82	.45	.20	.0009	78	100	.71	.46	.0169
FLCS	67	83	1.09	1.02	.1999	75	104	1.08	1.10	.8073	63	81	1.11	1.04	.1647	77	101	1.21	1.07	.0098
FMCS	65	81	1.11	1.04	.1129	80	103	1.29	1.06	.0003	62	80	1.11	1.06	.3467	77	101	1.21	1.09	.0074
FPS	69	82	1.03	1.02	.8966	81	104	1.07	1.08	.9979	64	79	1.02	1.00	.7351	81	103	1.10	1.11	.9711
PDL	50	39	.54	.15	.0011	69	66	.91	.26	.0000	42	41	.55	.22	.0065	56	62	.89	.29	.0000
PVL	49	39	.53	.03	.0001	68	66	.81	.21	.0000	44	41	.50	.05	.0002	58	63	.78	.14	.0000
PAS	53	39	.96	1.00	.4017	72	66	1.15	.95	.0004	45	41	.98	.98	.9604	61	63	1.11	.95	.0120

degenerative changes between the sexes than between the sides. It is noteworthy that the femoral patellar surface shows a higher mean for Indian Knoll males at a nonsignificant level while its adjacent articulating surface, the articular surface of the patella, had a higher mean on the Averbuch sample at a significant level. The females exhibited a similarly interesting pattern of involvement with the Averbuch sample having a higher mean on the femoral surface and the Indian Knoll sample having an equal or higher mean on the patellar surface.

Bone and Joint Totals

The variables of each element were added together to arrive at a bone total. These three figures were summed to produce a total for the joint. The probabilities of the means being the same for the variables tibia, patella, distal femur, and knee by the three agegroups, twenties, thirties, and overforties, and with the ages combined are shown in Table 5.6.

The bone and joint totals were examined for the intensity of degenerative changes in the none/slight, moderate and severe degrees of involvement both by the previously mentioned agegroups and with all ages combined. The gradations were chosen to correspond as closely as

TABLE 5.6

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME.
BONE AND JOINT TOTALS BY AGEGROUPS
WITH SEXES AND SIDES COMBINED

Variable	Twenties					Thirties					Overforties					Ages Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
Tibia	72	100	3.33	2.50	.0000	22	134	4.05	2.96	.0009	15	33	4.73	3.88	.1477	113	267	3.65	2.90	.0000
Patella	117	75	1.88	1.07	.0000	59	103	3.15	1.41	.0000	28	30	3.50	1.77	.0000	210	208	2.50	1.34	.0000
Femur	82	113	3.10	1.65	.0000	34	161	4.47	2.10	.0000	19	49	4.68	2.82	.0007	143	323	3.69	2.05	.0000
Knee	38	61	10.00	6.98	.0000	13	67	10.15	7.99	.0027	4	12	10.00	11.17	.6214	56	140	10.09	7.82	.0000

possible with those depicted in the <u>Atlas of Standard Radiographs of Arthritis</u> (1963). The degree of severity was coded as follows:

Knee Degree of Involvement

	None/slight 1	Moderate 2	Severe 3
Proximal Tibia	0-3	4-7	8-13
Distal Femur	0-3	4-7	8-16
Patella	0-1	2-4	5-9
Knee	0-7	8-17	18-26

In the following tables the degree of severity is represented numerically; i.e. none/slight is 1, moderate is 2, and severe is 3. The frequencies, Chi-square approximations and probabilities were computed utilizing the FREQUENCY procedure (SAS Institute Inc. 1985).

It is apparent that even in the first agegroup twenties, Table 5.7, the Averbuch sample has a higher degree of involvement than Indian Knoll. Since this agegroup includes individuals 19 years to 29 years the first signs of deterioration on the bone surfaces began almost as soon as the epiphyses were fused. It must be realized that the age of onset as discussed by osteologists is the age of the individual when the first osseous changes can be perceived. A considerable amount of cartilage destruction has preceded the changes on the bone surfaces.

TABLE 5.7

KNEE: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP TWENTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	72	65.28	31.94	02.78	100	88.00	12.00	00.00	13.714	.001	2
Patella	115	47.83	52.17	00.00	75	89.33	10.67	00.00	34.032	.000	1
Femur	108	44.86	52.34	02.80	119	74.79	25.21	00.00	21.973	.000	2
Knee	38	28.95	65.79	05.26	61	72.13	27.87	00.00	13.714	.001	2

The distal femur is more heavily involved than the other components in both samples, the patella is second in the Indian Knoll group and the tibia is second in the Averbuch sample.

The agegroup thirties, Table 5.8, is beginning to show a slightly different pattern. The patella in the Averbuch sample has more frequent involvement than the other elements while the distal femur at Indian Knoll is more affected. Close to 10% of the Averbuch sample has severe degenerative changes on the tibia and femur. A smattering of severely affected elements, notably the tibia and distal femur, are found in the Indian Knoll sample.

Table 5.9 indicates that the distal femur is the most frequently involved element in the overforties agegroup for both samples. The patella still has a zero frequency rate for the severe degree of degenerative changes.

One study of samples confined to the older agegroups indicates that after the age of 60 years the frequency of involvement of the knee does not rise appreciably with the ensuing decades (Forman et al. 1983). More women experienced severe abnormalities than men; Chi-square = 6.296; p=0.012 for blacks and Chi-square = = 10.427; p=0.001 for whites. This investigation included

TABLE 5.8

KNEE: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP THIRTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	22	36.36	30.00	09.09	134	77.61	20.90	01.49	17.079	.000	2
Patella	46	21.74	78.26	00.00	103	64.08	35.92	00.00	22.810	.000	1
Femur	55	25.45	63.64	10.91	176	54.55	44.89	00.57	25.220	.000	2
Knee	13	15.38	84.62	00.00	67	55.22	44.78	00.00	6.916	.009	1

TABLE 5.9

KNEE: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN
AGEGROUP OVERFORTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	15	40.00	40.00	20.00	33	69.70	18.18	12.12	3.908	.142	2
Patella	18	22.22	77.78	00.00	30	53.33	46.67	00.00	4.480	.034	1
Femur	18	11.11	77.78	11.11	57	40.35	54.39	05.26	5.458	.065	2
Knee	4	75.00*	00.00*	25.00*	12	41.67	33.33	25.00	2.000	.368	2

* This figure is of questionable value due to the size of the sample from Averbuch at this agegroup (n=4).

the clients of fifteen senior citizen centers in Brooklyn, New York.

It is apparent in Table 5.10 that the distal femur is the most heavily involved element in both samples when the agegroups, sexes, and sides are examined together. This finding is consistent with other archaeological studies which find the distal femur more involved than the other elements (Jurmain 1975). Hrdlicka (1914) found 36 of 1210 Peruvian femora (2.9%) with some degree of change and 12 of 781 tibiae (1.5%) with arthritic development, patellae are not mentioned.

Gupta et al. (1979) found that the articular surfaces of the femur, the patella, and the tibial condyles were affected in that order in an autopsy study in India. This same order is found in the Averbuch and Indian Knoll samples. However, the tibia is slightly more involved at the severe range in each of these prehistoric series than is the distal femur. Severely affected patellae are conspicuously absent from both of these samples.

A common finding in other studies is that the femoral surface of the patella is the most severely involved of the knee elements (Kilgore 1984). Jurmain (1975) noted that in the Terry collection both black and white samples were consistently the most affected while

TABLE 5.10

KNEE: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS WITH AGEGROUPS, SEXES,
AND SIDES COMBINED

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	109	55.96	37.61	06.42	267	80.52	17.23	02.25	24.165	.000	2
Patella	179	38.55	61.45	00.00	208	71.63	28.37	00.00	42.816	.000	1
Femur	180	35.56	58.33	06.11	352	59.09	39.77	01.14	32.266	.000	2
Knee	55	29.09	65.45	05.45	140	61.43	36.43	02.14	16.758	.000	2

among the archaeological samples from the Pecos series and the Eskimo series the femur was the most affected element; individuals from the Pecos series were the least affected. He suggests that local stress is the activating agent producing the higher incidence of degenerative changes on the bone.

Thould and Thould (1983) found a 9% frequency of knee involvement in a Roman Britain archaeological sample. Wells (1965) described two examples of knee osteoarthritis in an early Anglo-Saxon archaeological sample. He felt that the onset of osteoarthritis in the knee was earlier among these people than those of modern time.

In a metal age sample from Iran and Iraq, Rathbun reported a 27% frequency of osteoarthritis in the knee (1984). In a comparative study of Danish prehistoric archaeological samples, Bennike (1985) found an overall frequency of 6.5% with all ages and sexes combined. Her data are based on osteophytic growth within the joint; porosity, pitting, and eburnation were not addressed.

The Crow Creek Massacre site, a prehistoric Amerindian site in South Dakota, contained over 486 individuals whose remains had been disarticulated and mixed together (Zimmerman et al. 1981). The knee was the most commonly affected joint for osteoarthritis; no frequencies were given.

As can be seen from Table 5.11, a slightly different pattern emerges when the sexes are separated and the category "severe" is examined. The tibia consistently is the most severely involved element in both sexes and population samples. No incidence of severe deterioration of the patella is seen in either sex or sample. However when the "moderate" and "severe" categories are combined the distal femur exhibits the most involvement except for the male Averbuch sample which has a higher degree of involvement on the patella.

Most clinical studies of osteoarthritis of the knee are limited to individuals in their later years since the disease is age-related. The pattern of involvement changes as the years progress not only for primary osteoarthritis but also for the pattern of injury-related secondary arthritis in athletes (Grossman and Nicholas 1977). Lederman (1983) examined 3309 patients suffering from osteoarthritis and found the females with almost double the frequency of the males particularly in the over fifty-five age group (Chi =13.16). This investigation of hospital outpatients in Brazil included the age range of thirty-nine to eighty years.

Meachim and Pedley (1980) realized a 57% frequency of knee osteoarthritis in women and 15% in men in a necropsy study of individuals 70-96 years in Liverpool,

TABLE 5.11

KNEE: COMPARISON OF FREQUENCIES OF BONE TOTALS BY SEX.
AGEGROUPS AND SIDES COMBINED.

	Female										
	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	58	58.62	37.93	03.45	126	89.68	09.52	00.79	23.858	.000	2
Patella	82	48.78	51.22	00.00	80	77.50	22.50	00.00	14.323	.000	1
Femur	91	38.46	58.24	03.30	155	72.90	26.45	00.65	28.949	.000	2
Knee	25	32.00	64.00	04.00	56	80.36	19.64	00.00	18.619	.000	2

	Male										
	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	51	52.94	37.25	09.80	141	72.34	24.11	03.55	7.257	.027	2
Patella	97	29.90	70.10	00.00	128	67.97	32.03	00.00	32.025	.000	1
Femur	90	33.33	57.78	08.89	197	48.22	50.25	01.52	12.555	.002	2
Knee	30	26.67	66.67	06.67	84	48.81	47.62	03.57	4.528	.104	2

England. A much lower frequency rate but a similar sex ratio was discussed by Hoaglund et al. (1973), they found 2% of the males and 7% of the females in a Hong Kong Chinese sample with knee osteoarthritis.

Five samples from populations in Northern Europe showed a similar relationship radiographically between males and females for the distribution of osteoarthritis in the knee, 19% in males and 30% in females. The most northerly males displayed the least amount of joint deterioration in all joints studied (Lawrence and Sebo 1980).

Gresham and Rathey (1975) examined the knee joints of seventy-five individuals between the ages of 60 and 104 in the Eastern United States. A frequency of 70% involvement at the minimum to severe range appeared with roentgenographic changes; no essential differences between the sexes appeared. Yet in a survey of a Dutch population sample of 10000 individuals, a "...clearcut excess of radiological OA is observed in women...." (Valkenburg 1983:20). Miners showed a 6% severe involvement to the manual workers' 2% in Kellgren and Lawrence's (1952) investigation which was limited to males in the fifth decade.

Martin et al. (1979) found that the degenerative changes in the knee increased dramatically from age 35 until there was a 100% involvement by age 50 in the archaeological sample from Dickson Mound.

Larsen's (1984) comparison of prehistoric non-agriculturalist and agriculturalists on the Georgian coast revealed a decrease in frequency among both males and females; the males went from 18.6% to 12.6% and females from 15% to 3.4% frequencies.

In the Terry collection which is a modern American sample, Jurmain (1975) found that the females were consistently more affected than males; p=.0001 for the right knee, p=.0008 for the left. The prehistoric Pecos sample were slightly more affected on the left side.

A higher rate of knee osteoarthritis in males than females was found in an East African survey of patients complaining of polyarthritic symptoms at an outpatient hospital in Nairobi (Bagg et al. 1976).

The frequency of the degree of involvement by sides is tabulated in Table 5.12. Among the affected elements on the left side, the patella is the most frequently involved at Averbuch and the distal femur at Indian Knoll. On the right the distal femur is the most affected element in both samples. The left knee is more frequently involved and more severely affected than the right one in both sample series. The Averbuch sample

TABLE 5.12

KNEE: FREQUENCY OF INVOLVEMENT BY SIDE

Left Knee

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	59	59.32	32.20	08.47	136	80.15	17.65	02.21	10.312	.006	2
Patella	98	37.76	62.24	00.00	105	72.38	27.62	00.00	24.626	.000	1
Femur	91	40.66	53.85	05.49	179	62.57	36.31	01.12	14.099	.001	2
Knee	30	26.67	66.67	06.67	73	60.27	38.36	01.37	10.462	.005	2

Right Knee

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Tibia	50	52.00	44.00	04.00	131	80.92	16.79	02.29	15.551	.000	2
Patella	81	39.51	60.49	00.00	103	70.87	29.13	00.00	18.209	.000	1
Femur	90	31.11	62.22	06.67	173	55.49	43.35	01.16	17.606	.000	2
Knee	25	32.00	64.00	04.00	67	62.69	34.33	02.99	6.993	.030	2

exhibits a more severe degree of involvement for all the knee variables.

The females in Kilgore's (1984) Nubian study had an incidence of 34.5% involvement in the left knee compared with 18.7% of the males; this difference was not statistically significant. The left patella was involved in 66.6% of the sample for the females and the right patella in 55%; the males' pattern was different with the right patella being involved in 52.8% and the left in 43.7%.

In this investigation of the differences in the pattern of involvement between two skeletal series, the differences controlling for sex and controlling for side are given in Tables 5.13 and 5.14. A consistent pattern among the females is noted with a p=.0000 for all variables in Table 5.13.

The probability figures for the males are only slightly less significant with the variables tibia (p=.0084) and the knee itself (p=.0033) not being very highly significant.

The comparison of the samples by side, Table 5.14, reveals the consistent statistical significance of the differences between the skeletal series. The Averbuch sample always has a higher mean of the degree of involvement in the knee.

TABLE 5.13

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
BY SEX

Variable	Female					Male				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Tibia	60	126	3.43	2.52	.0000	53	141	3.89	3.25	.0084
Patella	90	80	2.03	1.21	.0000	120	128	2.84	1.41	.0000
Femur	94	155	4.14	3.36	.0000	95	197	4.58	3.82	.0000
Knee	25	56	9.48	6.77	.0000	31	84	10.58	8.52	.0033

TABLE 5.14

KNEE: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE

Variable	Left					Right				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Tibia	60	136	3.72	2.88	.0005	53	131	3.57	2.92	.0008
Patella	113	105	2.50	1.33	.0000	97	103	2.48	1.34	.0000
Femur	93	179	4.23	3.57	.0001	96	173	4.49	3.67	.0000
Knee	30	73	10.30	7.93	.0012	26	67	9.85	7.70	.0001

The pattern of symmetry of the degree of right and left involvement in the knee differs between these two populations. The females of Indian Knoll exhibit a 72.22% symmetrical involvement while the females of Averbuch show a 60% involvement. The males differ more with Indian Knoll having an 86.36% symmetry and Averbuch a 100% These figures correspond relatively well with Jurmain's (1975) figure of 81% symmetry of degree of involvement in a mixed sample of four skeletal series.

Of the females of Indian Knoll who exhibited differing degrees of wear on each side, 80% had none/slight involvement on the left and moderate involvement on the right. Only 20% showed moderate involvement on the left and none/slight on the right. The females at Averbuch were even in the two patterns, 50% showed none/slight on the right and moderate on the left and 50% the opposite pattern.

Of the males at Indian Knoll who had asymmetric patterns 60% showed moderate wear on the left and none/slight on the right, and 33% had moderate on the left and severe on the right. The males at Averbuch showed no asymmetrical patterns; this may be an artifact of the small sample size of complete knee joints.

Combining the sexes Averbuch shows an 83.33% symmetry in the degree of wear while Indian Knoll shows an

80.00% correspondence of symmetrical degree of involvement.

Examining the two populations separately there is no statistical difference between the means of the sides for the knee joint or its three components at the p=0.05 level. The probabilities of the means of the sides being the same are shown in Table 5.15.

Meachim et al. (1980) found that in patients with idiopathic osteoarthritis of the hip, many also were afflicted with knee osteoarthritis. Of these 88% of the women were affected bilaterally in the knee joint and 46% of the men.

As is indicated in Table 5.16 a consistent degree of heavier involvement in the knee joint and its three components was found among the males than the females of both populations in this study. In the Averbuch sample only the patella is statistically significant at the p=.0001 level. At Indian Knoll the knee and the two elements other than the patella are statistically significant at the p=.0000 level.

It would appear that the type of stress on the knee joint is more similar between the males and females at Averbuch than at Indian Knoll.

Several studies have investigated the possibilities of particular cultural activities which

TABLE 5.15

KNEE: PROBABILITIES OF THE MEANS OF THE SIDES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Left	Right	Left	Right		Left	Right	Left	Right	
Tibia	60	53	3.57	3.72	.8457	136	131	2.92	2.88	.8341
Patella	113	97	2.50	2.48	.8777	105	103	1.33	1.34	.8910
Femur	93	96	4.23	4.49	.1751	173	179	3.67	3.57	.2620
Knee	30	26	9.85	10.30	.9868	73	67	7.93	7.70	.5454

TABLE 5.16

KNEE: PROBABILITIES OF THE MEANS OF THE SEXES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Male	Female	Male	Female		Male	Female	Male	Female	
Tibia	60	53	3.89	3.43	.2489	144	126	3.25	2.52	.0000
Patella	120	90	2.84	2.03	.0001	128	80	1.41	1.21	.1112
Femur	95	94	4.58	4.14	.2671	197	155	3.82	3.36	.0000
Knee	31	25	10.58	9.48	.3349	84	56	8.52	6.77	.0000

might increase the amount and type of stress on the knee joint. Chantraine (1985, 1986)(Anderson 1986) examined eighty-one veteran soccer players for radiological and clinical evidence of osteoarthritis. The results indicated that the increase in prevalence with age rose in a proportion greater in the soccer players than in the general public.

Long distance running was ruled out as associated with clinical osteoarthritis in a cross-sectional study by Lane et al. (1986) although the authors did suggest that those individuals with osteoarthritis simply did not participate in such activities. The results of a similar study (Panush et al. 1986) agreed with this conclusion. The results of Sohn and Micheli (1985) agree; they found a 2% prevalence rate of severe pain in former cross-country runners and a 2% rate in former swimmers. In another investigation of middle and long distance runners with knee pain the number of years spent training was statistically significantly associated with the affected group ($p<0.05$) (McDermott and Freyne 1983).

No differences in radiological findings in the knee joint were found between lumberjacks and a control group in Finland (Sairanen et al. 1981). The age range of the sample was 22-65 years and the average length of employment as lumberjacks was 20 years.

Solonen (1966) examined 60 rugby players in Finland to determine the pattern of osteoarthritic changes among them. Twenty-eight percent showed signs of slight or moderate knee involvement radiographically, 92% were affected in the ankle joint. Another study of football players in Denmark found no differences in the rate of involvement of the knee joint between the football players and a control group. (Klunder et al. 1980).

Swimmers who utilized the whipkick in the breaststroke for more than eight years were symptomatic for osteoarthritis of the knee but had no radiographic findings (Stulberg et al. 1980). Forty-three percent of a sample of French wrestlers examined for osteoarthritic changes were affected at the knee (Layani et al. 1960).

Weight-lifters who had been active in the sport for six years or more and were of a national or international standard exhibited more degenerative changes in the knee than the other joints (Fitzgerald and McLatchie 1980). A 20% frequency of Grade 1 changes, 6% of Grade 2, and 6% of Grade 3 were computed for the femoro-tibial articulation.

A comparative study of miners and non-miners in England resulted in the conclusion that some component in the mining activity resulted in an increase of osteoarthritis among the miners (Lawrence 1955). Kneeling and the duration of kneeling were found not to be factors. There was a close relationship between an increase in body weight and "...doubtful and minimal..." radiological changes in the knee joint (Lawrence 1955:257). Pain was also more frequent in the miners (Lawrence and Aitken-Swan 1952). An interesting secondary result of this study was the finding that the families of miners had a lower incidence of complaints of general osteoarthritis than the general public and considerably lower than the miner sample.

Among living hunters and gatherers the elderly Kalahari San are characterized as sometimes being affected by mild osteoarthritis in the knee joint (Truswell and Hansen 1976).

A sample of Eskimos from the East coast of Greenland compared with a sample of mixed Eskimo-European population from the West coast revealed that significantly more individuals from the mixed population were affected with osteoarthritis than those of pure Eskimo ancestry (Andersen and Winckler 1979), 38% and 19% respectively. The authors suggest that the difference may be related to occupations; the West coast sample is from an industrialized area which has assimilated the European style of living and the East coast sample still practices the traditional hunting and fishing. This difference combined with genetic predisposition may explain the difference.

CHAPTER VI

THE HIP JOINT

Degenerative Changes

The hip is the largest weight-bearing joint in the human body. The ball and socket joint is more stable than the other ball and joint socket, the shoulder, due to the ligamentous capsule which deters the migration of the head of the femur from the deep socket. The head of the femur is not spherical but flattened in an approximate anterior posterior direction (Rydell 1973).

In general it has been established that patients with osteoarthritic changes, particularly severe ones, are unlikely to suffer from osteoporosis or femoral fractures (Solomon et al. 1982, Weintroub et al. 1982).

The hip is the most common site of severe osteoarthritis in humans (Harrison et al. 1953). The destruction of the cartilage is followed by joint narrowing, sclerosis, formation of cysts, and formation of osteophytes. There is some controversy concerning whether the presence of osteophytes is useful as a diagnostic tool in osteoarthritis of the hip (Nilsson et al. 1982).

Cameron and MacNab (1975a) differentiate between two types of osteoarthritis of the hip, migratory and non-migratory. The head of the femur remains within the acetabulum in the non-migratory type; in the migratory group, the head of the femur drifts. Most commonly the femur moves upward and outward, but there are cases where the head of the femur moves medially and down. Migration of the femoral head is associated with joint space narrowing and, it appears, is determined by the anatomy of the acetabulum (Resnick 1975, 1976).

There is some evidence that an increase in the anteversion angle may predispose an individual to later development of coxarthosis (Terjesen et al. 1982). Increased anteversion of the femoral neck may also be secondary to the destructive changes of osteoarthritis (Reikeras and Hoiseth 1982).

A change in the distribution or amount of joint pressure creates the need for a compensating alteration within the joint. The condensed bone on the roof of the acetabulum may be altered by the abnormal stress created by this change in pressure (Knodt 1964).

When making comparisons between the results of two or more researchers concerning the incidence and frequency of osteoarthritis, it is imperative to take into consideration the diagnostic methods and method of sample selection. Since coxarthrosis is a disease of the elderly, the ages of the individuals within the sample must be considered.

Clinical studies of degenerative hip disease are normally limited to the upper age groups (Danielsson 1964, Hoaglund et al. 1973, Solomon et al. 1976, Pogrund et al. 1982, Solomon et al. 1982, Terjesen et al. 1982). The disease is equally common in men and women in the mild form, but takes a more severe course in women (Nilsson et al. 1982).

Clinically women are more severely affected than men (Jørring 1980). Meachim et al. (1980) state that the disease is twice as common among women as among men. Jørring agrees that severe osteoarthritis is twice as prevalent in females as in males in age groups over 60 (1980). In a survey of seventeen population samples from 54^{o} North to 26^{o} South, the hip joint was included in the x-ray analysis in twelve samples (Lawrence and Sebo 1980); the combined population prevalence rates for the age 55+ were 14% for males and 13% for females.

Hoaglund et al. (1973) examined the frequencies of coxarthrosis in a southern Chinese population in Hong Kong. Frequencies were considerably lower than Caucasian groups; their results show 1.21% among the males and 0.8% among the females. Only individuals above the age of 55 years were included.

Pogrund et al. (1982) examined a random sample in Jerusalem for the prevalence of osteoporosis and osteoarthritis of the hip. All subjects were over 45 years of age. No coxarthrosis was found in either sex under the age of 54 years. In the over 54 year age group a 4.1% involvement was noted. No significant relationship with ethnic origin was found.

About half of the patients with radiological changes exhibit symptoms which require treatment (Jørring 1980). The highest incidence of the onset of symptoms varies with sex. The results of a clinical study by Macys et al. (1980) found the highest incidence of the onset of symptoms of females was in the sixth decade while in males the highest incidence was the fifth decade. By the time the disease becomes symptomatic a considerable amount of destruction has occurred in the joint.

Trochanteric pain is the most common complaint, although it is common with patients without coxarthrosis also. Loss of range of motion is another early sign in all hip conditions (Nilsson et al. 1982), although loss of range of motion is also highly statistically significant with increasing age ($p=0.001$) (Allander et al. 1974).

Comparison of Original Variables

Ten discrete areas within the hip were examined for porosity, pitting, osteophytic lipping, and eburnation; six on the proximal femur and four on the acetabulum.

Proximal Femur

a. FLT - Lipping around the fovea capitis

b. FLH - Marginal lipping around head

c. FIL - Remodeling of intertrochanteric line

d. FTF - Remodeling of trochanteric fossa

e. FASS - Shape of the articular surface on the head

f. FASC - Condition of the articular surface on the head

Acetabulum

a. AR - Remodeling of rim

b. AF - Fossa

c. AAS - Articular surface

d. AIL - Condition of iliofemoral area

See Appendix B for illustrations and method of scoring.

Because there is a correlation between age and the onset of osteoarthritis, particularly osteoarthritis of the hip or coxarthritis, the samples in this investigation were examined by agegroups as well as with the agegroups combined.

In the agegroup twenties, Table 6.1 describes the probability of the means being the same. The probabilities are based on a Z score computed utilizing the NPAR1WAY software program of SAS Institute Inc.(1985).

The relationship between the males and females is

TABLE 6.1

HIP: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP TWENTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
FLT	88	66	.53	.23	.0011	101	59	.84	.15	.0000	189	125	.70	.19	.0000
FLH	84	67	.15	.00	.0008	101	58	.12	.03	.0723	185	125	.14	.02	.0003
FIL	45	63	.47	.10	.0000	54	52	.59	.29	.0017	99	115	.54	.18	.0000
FTF	53	65	.49	.23	.0203	66	53	.55	.25	.0015	119	118	.52	.24	.0001
FASS	74	67	.12	.06	.2075	101	59	.22	.02	.0007	175	126	.18	.04	.0004
FASC	88	67	.97	.97	.9160	103	59	.98	1.02	.1042	191	126	.97	.99	.3761
AR	66	67	.83	.01	.0000	80	58	1.11	.05	.0000	146	125	.99	.03	.0000
AF	67	61	.13	.00	.0032	69	53	.14	.00	.0066	136	114	.14	.00	.0001
AAS	72	67	1.00	.99	.7663	89	57	1.17	.91	.0004	161	124	1.09	.95	.0011
AIL	51	64	.63	.06	.0000	66	53	.80	.19	.0000	117	117	.73	.12	.0000

very similar at this early age. The means of the Averbuch sample consistently are higher than those of Indian Knoll. The exception is the femoral head condition. The female means are even while the male mean is higher for Indian Knoll. The variables for the females describing the femoral head shape, condition of the femoral head, and the articular surface of the acetabulum are not statistically significant at any level.

The males sample shows a variation in the variables which have statistical significance with the femoral head lipping and femoral head condition having little statistical significance.

With the sexes combined, only the condition of the femoral head is not significant at some level (p=.001).

Murray and Duncan (1971) examined athletic activity in adolescents. Their research was designed to determine if there was a relationship between various athletic endeavors of young adult males and the early onset of osteoarthritis of the hip. The tentative conclusion reached was that "...excessive athletic activity in adolescence is likely to be an important cause, certainly in males, of subsequent degenerative hip disease." (1971:418). Their results also showed a relationship with tilt deformity in the young men and a statistical relationship with a history of growing pains.

For the agegroup thirties, Table 6.2 expresses the probabilities of the means being the same between the two population samples. The difference in the amount of osteoarthritic change in this agegroup is still highly statistically significant except for the variable describing the condition of the femoral head (p=.0272 and p=.9031). The means of this variable in the male sample are even while the mean of the female sample is higher for the Averbuch sample. This variable is the only one not highly statistically significant (p=.0000) for the combined sample (p=.2873).

Symptomatic hip osteoarthritis is rare before the age of fifty, so an early onset of a severe nature by the thirties implicates chronic trauma in the pathogenesis of this disease (Hellmann et al. 1983). Four of fifty-two classical ballet dancers from the ages of twelve to forty-one displayed bilateral hip osteoarthritis in a radiological survey conducted in Cincinnati, Ohio (Schneider et al. 1974). Stress fractures, talar spurring, and cortical thickening of the bone shafts were other evidences of stress occurring in this occupational group.

By the time the agegroup overforties is reached the differences between the two populations as indicated in Table 6.3 are not as distinct. The females show no statistically significant difference in the means for four

TABLE 6.2

HIP: PROBABILITIES OF THE MEANS BEING THE SAME FOR AGEGROUP THIRTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
FLT	34	91	.76	.46	.0073	41	95	1.27	.53	.0000	75	186	1.04	.49	.0000
FLH	35	92	.40	.13	.0008	39	98	.36	.07	.0001	74	190	.38	.10	.0000
FIL	22	77	.73	.17	.0000	23	91	1.00	.26	.0000	45	168	.87	.22	.0000
FTF	28	86	.86	.37	.0003	25	94	.84	.27	.0000	53	180	.85	.32	.0000
FASS	38	92	.39	.00	.0000	39	98	.38	.05	.0000	77	190	.39	.03	.0000
FASC	38	93	1.05	1.00	.0272	41	98	.98	.98	.9031	79	191	1.01	.99	.2873
AR	40	82	1.07	.16	.0000	33	99	1.30	.13	.0000	73	181	1.18	.14	.0000
AF	37	78	.43	.00	.0000	33	91	.52	.01	.0000	70	169	.47	.01	.0000
AAS	42	82	1.14	1.00	.0074	38	100	1.24	.97	.0002	80	182	1.19	.98	.0000
AIL	27	78	.78	.37	.0029	24	91	1.13	.53	.0000	51	169	.94	.46	.0000

TABLE 6.3

HIP: PROBABILITIES OF THE MEANS BEING THE SAME FOR AGEGROUP OVERFORTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
FLT	25	15	.88	.67	.5133	23	46	1.57	.72	.0000	48	61	1.21	.70	.0010
FLH	25	18	.24	.22	.9063	22	48	.32	.13	.0349	47	66	.28	.15	.0741
FIL	9	12	1.00	.00	.0004	17	43	.94	.30	.0000	26	55	.96	.24	.0000
FTF	14	16	.72	.50	.3549	16	47	1.25	.64	.0005	30	63	1.00	.60	.0043
FASS	24	18	.25	.06	.1023	24	48	.54	.04	.0000	48	66	.40	.05	.0000
FASC	26	17	.96	1.00	.6527	25	48	1.04	1.08	.9894	51	65	1.00	1.06	.5349
AR	21	17	1.19	.12	.0000	24	46	1.29	.37	.0000	45	63	1.24	.30	.0000
AF	19	14	.95	.00	.0002	23	39	.48	.08	.0143	42	53	.69	.06	.0000
AAS	23	17	1.26	1.12	.2776	24	46	1.42	1.11	.0017	47	63	1.34	1.11	.0020
AIL	13	14	1.15	.57	.0137	12	43	1.50	1.05	.0040	25	57	1.32	.93	.0026

of the six femoral variables, and two of four of the acetabular variables. Males exhibit a different pattern with only one variable being not significant at some level (p=.9894). The means of the Averbuch sample are still higher except for both males and females on the condition of the femoral head, these are not statistically significant.

With the sexes combined, the femoral head is not statistically significant at p=.5349 nor is lipping of the femoral head (p=.0741). The other variables are significant at p=.01 or better.

A consistent pattern of development is apparent with the initial differences in the female sample decreasing in a chronological fashion through the agegroups. The implication is that as the women age the activity patterns between the two population samples become more similar. Another interpretation is that the pattern of utilization of the hip corresponds at all adult agegroups with the Averbuch women undergoing substantial stress in adolescence.

When the agegroups, sexes and sides are combined in Table 6.4, Averbuch displays a higher mean on all variables at the highly significant level p=.0000 with the lone exception of the condition of the femoral head. The Indian Knoll sample mean is higher on that variable

TABLE 6.4

HIP: PROBABILITIES OF THE MEANS BEING THE SAME
WITH AGEGROUPS AND SIDES COMBINED

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
FLT	155	172	.66	.39	.0001	173	200	1.06	.46	.0000	328	372	.88	.43	.0000
FLH	152	177	.23	.09	.0005	171	204	.23	.07	.0000	323	381	.23	.08	.0000
FIL	81	152	.59	.13	.0000	99	186	.75	.28	.0000	180	339	.68	.21	.0000
FTF	99	167	.63	.33	.0002	113	194	.73	.35	.0000	212	361	.68	.34	.0000
FASS	144	177	.21	.03	.0000	173	205	.33	.04	.0000	317	382	.27	.03	.0000
FASC	160	177	.98	.99	.7208	178	205	.99	1.01	.3914	338	382	.99	1.00	.3853
AR	131	166	.95	.10	.0000	140	203	1.20	.16	.0000	271	369	1.08	.13	.0000
AF	125	153	.35	.00	.0000	129	183	.33	.02	.0000	254	336	.34	.01	.0000
AAS	141	166	1.09	1.01	.0288	155	203	1.24	.99	.0000	296	369	1.17	.99	.0000
AIL	93	156	.73	.26	.0000	104	187	.98	.55	.0000	197	343	.86	.42	.0000

although not at a statistically significant level (p=.3853).

Controlling for sex, the Averbuch variables show a statistically higher mean (p=.001) among the females except for the condition of the femoral head (p=.7208) and acetabular articular surface (p=.0288).

Among the males, the femoral head is the lone insignificant variable (p=.3914). The Indian Knoll mean is higher for the femoral head condition in both the male and female samples.

The means of the two samples were compared by sex and side and the statistical probabilities are listed in Table 6.5. It is evident that the pattern of female involvement does not vary appreciably between the sides. The Averbuch sample exhibits a higher mean on each of the variables except the femoral head surface condition where the Indian Knoll mean is higher on the left and the means are equal for the right.

The right male sample differentiates at a highly statistically significant level between the means of the two archaeological samples except for the aforementioned femoral head surface condition. On the left side, the males exhibit a non-significant level of statistical probability for the variable describing lipping around the femoral head. The femoral head surface condition has

TABLE 6.5

HIP: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE AND SEX, AGEGROUPS COMBINED

Variable	Left										Right									
	Females					Males					Females					Males				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
FLT	79	86	.63	.38	.0090	91	101	1.05	.49	.0000	76	86	.70	.40	.0054	82	99	1.07	.43	.0000
FLH	77	90	.21	.09	.0297	88	102	.22	.10	.0153	75	87	.25	.09	.0062	83	102	.24	.05	.0003
FIL	38	76	.55	.09	.0000	56	95	.70	.24	.0000	43	76	.63	.16	.0000	43	91	.81	.32	.0000
FTF	47	83	.53	.30	.0154	59	98	.63	.31	.0005	52	84	.71	.36	.0042	54	96	.83	.40	.0000
FASS	74	90	.16	.02	.0015	78	103	.31	.03	.0000	70	87	.26	.03	.0000	84	102	.35	.05	.0000
FASC	82	89	.98	.99	.6720	92	103	.98	1.04	.1028	78	88	.99	.99	.9561	86	102	1.00	.99	.7336
AR	65	84	.92	.10	.0000	71	102	1.15	.16	.0000	66	82	.98	.10	.0000	69	101	1.25	.17	.0000
AF	60	79	.30	.00	.0000	66	91	.26	.02	.0000	65	74	.40	.00	.0000	63	92	.40	.02	.0000
AAS	69	84	1.04	1.00	.3838	79	102	1.25	.98	.0000	72	82	1.13	1.01	.0323	76	101	1.22	.99	.0001
AIL	43	77	.72	.23	.0000	49	92	.86	.54	.0018	50	79	.74	.29	.0000	55	95	1.09	.56	.0000

a higher mean for the Indian Knoll sample although not at a significant level (p=.1028).

It is interesting to note that although the difference of the femoral head surface condition means are not statistically significant at any level, the means of the opposing articular surface, the acetabular surface, are highly significant at p=.0001 for the right side and p=.0000 for the left.

Bone and Joint Totals

Bone totals were computed by adding the variables of each element together, and the sums of the proximal femur and acetabulum were totaled to produce a figure for the hip joint. The probabilities of the means of the proximal femur, acetabulum, and hip joint being the same between the two samples are listed in Table 6.6.

The bone and joint totals were divided into three groups describing the degree of involvement: none/slight, moderate, and severe. The groupings were chosen to correspond with those depicted in the Atlas of Standard Radiographs of Arthritis (1963).

Numerals will be utilized in the following tables to depict the degree of severity: none/slight 1, moderate 2, and severe 3. The frequencies were determined by the

TABLE 6.6

HIP: PROBABILITIES OF THE MEANS BEING THE SAME.
BONE AND JOINT TOTALS BY AGEGROUPS
WITH SEXES AND SIDES COMBINED

Variable	Twenties					Thirties					Overforties					Ages Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
Femur	107	119	3.93	3.31	.0000	55	176	5.00	3.59	.0000	18	57	5.11	4.37	.0007	189	352	4.36	3.62	.0000
Acetabu	92	109	2.96	1.13	.0000	45	159	3.84	1.57	.0000	21	47	4.95	2.51	.0000	159	315	3.50	1.56	.0000
Hip	46	99	6.00	2.81	.0000	23	137	8.57	3.68	.0000	8	36	9.50	5.44	.0005	77	272	7.13	3.60	.0000

FREQUENCY software program utilized by SAS Institute Inc.(1985).

The recodings were computed to represent the degree of severity as follows:

	Hip Degree of Involvement		
	None/slight 1	Moderate 2	Severe 3
Proximal femur	0-2	3-6	7-12
Acetabulum	0-2	3-5	6-8
Hip	0-4	5-10	11-18

Beginning with the twenties agegroup, Table 6.7, the acetabulum is the more involved element at Averbuch while the proximal femur is more involved at Indian Knoll. No Indian Knoll variable exhibited severe changes.

The fourth decade, Table 6.8, shows a steady progression of involvement for the bone totals. The acetabulum is still the more involved at Averbuch and the femur remains more involved at Indian Knoll. No severe changes are present in the Indian Knoll sample.

Degenerative joint disease in the hip is primarily a disease of the middle age rather than old age (Lloyd-Robert 1955). Table 6.9 tabulates the degree of severity in the overforties agegroups from Averbuch and Indian Knoll. The oldest agegroup, continues to show a progression in frequency of involvement of the elements.

TABLE 6.7

HIP: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP TWENTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	82	40.24	53.66	06.10	113	83.19	16.81	00.00	40.310	.000	2
Acetabulum	92	31.52	65.22	03.26	109	98.17	01.83	00.00	101.280	.000	2
Hip	46	26.09	67.39	06.52	99	90.91	09.09	00.00	63.914	.000	2

TABLE 6.8

HIP: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP THIRTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	34	17.65	61.76	20.59	161	72.67	27.33	00.00	56.607	.000	2
Acetabulum	45	13.33	68.89	17.78	159	90.57	09.43	00.00	111.702	.000	2
Hip	23	08.70	60.87	30.43	137	72.99	27.01	00.00	61.551	.000	2

TABLE 6.9

HIP: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP
OVERFORTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	19	21.05	52.63	26.32	49	38.78	59.18	02.04	10.517	.005	2
Acetabulum	21	04.76	57.14	38.10	47	61.70	36.17	02.13	26.351	.000	2
Hip	8	00.00	62.50	37.50	36	33.33	63.89	02.78	11.349	.003	2

Some severe degenerative changes are present in both samples in this age range.

Table 6.10 shows the frequency of involvement in the samples with ages, sex, and sides combined. A difference in pattern is obvious here with a higher frequency of involvement on the proximal femur in the Indian Knoll sample and a higher degree of involvement in the acetabulum in the Averbuch sample. Jurmain (1975) found a difference in pattern of involvement between the cadaver samples and archaeological samples. The cadaver samples, both black and white, exhibited a greater degree of wear on the proximal femur than on the acetabulum while the two archaeological samples, from the Pecos group and the Eskimo group, exhibited a greater degree of involvement on the acetabulum than on the proximal femur. Frequencies tabulated for a metal age sample from Iran and Iraq express an 11% rate for the hip (Rathbun 1984). The average age at death was low in this series as is true in many archaeological skeletal series.

Gejvall (1983) found femoral head involvement in 7 of 73 adult females in a medieval Swedish series and none in the 63 males.

By the age of 50, approximately 50% of both American men and women will have some degenerative changes in the hip (Leisen and Duncan 1979).

TABLE 6.10

HIP: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS WITH AGEGROUPS,
SEXES, AND SIDES COMBINED

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	135	31.85	55.56	12.59	323	71.21	28.48	00.31	80.425	.000	2
Acetabulum	158	22.78	65.19	12.03	315	88.89	10.79	00.32	210.428	.000	2
Hip	77	18.18	64.94	16.88	272	74.26	25.37	00.37	98.857	.000	2

The primary area within the hip joint displaying degenerative changes varies between populations (Jurmain 1975). Results of some studies indicate that external forces such as heavy labor may influence the frequency and degree of severity of coxarthrosis (Kellgren and Lawrence 1952). Lindberg and Danielsson (1984) found no confirmation of this in an investigation of three groups in Sweden. Three hundred thirty two laborers, three hundred fifty two white collar workers, and four hundred thirty eight controls were examined for degenerative disease of the hip. Frequencies of 3.3% blue collar workers, 3.1% white collar workers, and 1.6% of the controls prevailed.

A similar lack of difference between lumberjacks and a control group of clerical workers in Finland was documented; 5% of the lumberjacks and 7% of the control group exhibited osteoarthritic lesions in the hip (Sairanen et al. 1981).

In an investigation of male runners no statistically significant differences in osteophytes, cartilage thickness, or grades of degenerative changes were found between the runners or the control group (Panush et al. 1986). Similarly Sohn and Micheli (1985) found a 2% prevalence rate of severe pain among former cross-country runners and a 2.4% rate among former swimmers. The age range of the samples was 23 to 77 years with the mean being 57 years. Puranen et al. (1975) compared a group of Finnish championship runners with a control group and found that 4% of the athletes had primary osteoarthritis of the hip as did 8.7% of the controls.

The pattern of involvement detected in Table 6.10. holds true when the sexes are divided, Table 6.11. Ortner and Putschar (1981) state that the most severe degenerative changes are found on the femoral head. The findings in the current study are undoubtedly influenced by the lack of elderly representatives which have the highest rate of coxarthosis. The demographic pattern of a sample, whether archaeological or representative of a living population, must be delineated in investigations of epidemiological patterning if the study is to command credibility.

The pattern of involvement by side agrees with other research results with the right side having a slightly higher frequency of severe involvement than the left for Averbuch (Table 6.12). The results of Indian Knoll tabulations show no appreciable difference in laterality.

No major differences in side involvement were found by Bennike (1985) in her investigation of

TABLE 6.11

HIP: COMPARISON OF FREQUENCIES OF BONE TOTALS BY SEX.
AGEGROUPS AND SIDES COMBINED

	Female										
	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	61	42.62	50.82	06.56	147	78.91	21.09	00.00	30.739	.000	2
Acetabulum	78	30.77	58.97	10.26	147	91.84	08.16	00 00	93.009	.000	2
Hip	40	27.50	60.00	12.50	127	84.25	15.75	00.00	52.349	.000	2

	Male										
	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Femur	74	22.97	59.46	17.57	176	64.77	34.66	00.57	51.883	.000	2
Acetabulum	80	15.00	71.25	13.75	168	86.31	13.10	00.60	120.448	.000	2
Hip	37	08.11	70.27	21.62	145	65.52	33.79	00.69	53.679	.000	2

TABLE 6.12

HIP: FREQUENCY OF INVOLVEMENT BY SIDE

Left Hip

Variable	Averbuch N	1	2	3	Indian Knoll N	1	2	3	X2	Prob	DF
Femur	72	31.94	58.33	09.72	165	74.55	24.85	00.61	43.157	.000	2
Acetabulum	76	27.63	63.16	09.21	157	90.45	08.92	00.64	96.467	.000	2
Hip	40	20.00	67.50	12.50	137	78.10	21.17	00.73	49.746	.000	2

Right Hip

Variable	Averbuch N	1	2	3	Indian Knoll N	1	2	3	X2	Prob	DF
Femur	63	31.75	52.38	15.87	158	67.72	32.28	00.00	40.012	.000	2
Acetabulum	82	18.29	67.07	14.63	158	87.34	12.66	00.00	114.645	.000	2
Hip	37	16.22	62.16	21.62	135	70.37	29.63	00.00	52.084	.000	2

pathological changes in three early Swedish populations. Kilgore (1984) likewise found no statistically significant difference in side involvement although the percentage of involvement was always higher on the right at the moderate to severe level. She found that the Nubian sample exhibited a higher overall involvement, slight to severe, among the males on the left side.

Pfeiffer (1977) found 5 of 55 individuals with degenerative changes on the right femoral head, 0 of 51 on the left. In this skeletal series originating in the Great Lakes region of Canada, the males exhibited almost double the frequency of involvement both on the femoral head changes and changes around the fovea capitis.

With the sexes and sides separated, the means are always higher for Averbuch at the statistically significant level of p=.001. This is true at all three age levels and with all agegroups combined. Tables 6.13 and 6.14 present the figures, they are self-explanatory.

The symmetrical involvement of the hip in the Averbuch sample may reflect the incompleteness of the sample. Nine male skeletons retained both hips, eleven females. No asymmetries were evident in the males and two in the females, a frequency of 18%. The Indian Knoll sample was more complete, fifty nine males and fifty two females retained both hip joints. The males showed 16.9%

TABLE 6.13

HIP: PROBABILITIES OF THE MEANS BEING THE SAME
BY SEX

Variable	Female					Male				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Femur	65	147	3.06	1.84	.0000	78	176	4.21	2.23	.0000
Acetabulum	77	147	3.17	1.39	.0000	82	168	3.80	1.70	.0000
Hip	40	127	6.45	3.17	.0000	37	145	7.86	3.97	.0000

TABLE 6.14

HIP: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE

Variable	Left					Right				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Femur	76	165	3.53	1.98	.0000	67	158	3.87	2.13	.0000
Acetabulum	75	157	3.31	1.52	.0000	84	158	3.67	1.59	.0000
Hip	39	137	6.64	3.45	.0000	38	135	7.63	3.75	.0000

asymmetry and the females 7%. The asymmetry for all individuals is between the none/slight and moderate degree except for one male at Indian Knoll which is moderate to severe. No differences at the none/slight to severe degrees were found. The Indian Knoll females had a greater involvement on the right side, the Averbuch females on the left. The asymmetrical joints of the Indian Knoll males were divided evenly, five exhibited more deterioration on the left and five on the right.

With the sexes combined, Indian Knoll exhibits an asymmetry frequency of 13.5% while Averbuch has a 10%. Clinical studies indicate a high degree of bilaterality in coxarthrosis. Macys et al. (1980) found the incidence of bilateral disease in the hip to be 87.8% in males and 71% in females. Danielsson (1966) noted bilateral disease in 31 %, Lloyd-Roberts (1955) 50%, Aglietti (1977) 75%.

Klunder et al. (1980) found a high degree of bilaterality in both retired football players (63.33%) in Denmark and in the control group (63.15%).

Examining the bone and joint totals in each sample separately no statistical differences are found between the right or left sides in either sample at the p=.000 level. The figures are listed in Table 6.15.

Larsen (1980, 1984) found a decrease in degenerative joint disease in the hips when comparing a

TABLE 6.15

HIP: PROBABILITIES OF THE MEANS OF THE SIDES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Left	Right	Left	Right		Left	Right	Left	Right	
Femur	76	67	3.53	3.87	.3606	165	158	1.98	2.13	.1118
Acetabulum	75	84	3.31	3.67	.1840	157	158	1.52	1.59	.2704
Hip	39	38	6.64	7.63	.1912	137	135	3.45	3.75	.0194

non-agricultural to an agricultural Georgian group. The frequency declined from 4.1% to 0.3%. However when he divided the series by sex, the female sample declined from 4.3% to 0.00%, while the males' frequency increased from 0.00% in the preagriculturalist to 9.1% in the agriculturalists.

A low rate of disease in the hip joint of Anglo-Saxons and early post-Saxon agriculturalists in England was discussed by Wells (1963). He reported on three cases, one of osteoarthritis, the others were congenital dislocation and osteochondritis. In another report of Saxon and medieval skeletons, Rogers <u>et al</u>. (1981) discussed an incidence of 28% in the Saxon individuals and 10% in the medieval sample. There was a surprising degree of exuberant osteophytic growth within the hip. A frequency of 12% involvement in the hip joint was noted by Thould and Thould (1983) in an archaeological sample from Roman Britain.

A lesser degree of hip involvement was noted in the agricultural Pecos population than in either the Eskimo sample or the cadaver samples from the Terry collection discussed in Jurmain's (1975) dissertation. This was significant at the p=0.001 for both right and left hips. Louyot and Savin (1966) concluded that osteoarthritis of the hip appears more frequently and earlier in modern day agriculturalists than in those of other occupations.

Trueta (1964) feels that the low incidence of coxarthrosis among the Mexican aborigines and the Asiatic Indians is due to their habit of squatting. In a report from Nigeria, an incidence rate of 19.2% was found (Eborg and Lawson 1978). The authors relate the low incidence of coxarthrosis to the low levels of hip dysplasia, epiphysiolysis, and Legg-Perthes' disease.

In another survey from Africa, Solomon et al. (1976) examined a random sample of the population of a rural South African group over the age of 54 years. Only 0.03% of the men and 0.02% of the women expressed radiological signs of osteoarthritis in the hip. The authors suggest that some of the predisposing disorders for women such as congenital dislocation, subluxation, and acetabular dysplasia may be absent in the population.

Solonen (1966) found no pathological changes radiographically in the hip in a study of rugby players ranging in age from 18-37 with an average length of active participation being 13 years.

In the present study, the means of the bone and joint totals are higher for the males at both archaeological sites. As is indicated in Table 6.16, the males show a consistently higher degree of involvement

TABLE 6.16

HIP: PROBABILITIES OF THE MEANS OF THE SEXES
BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Male	Female	Male	Female		Male	Female	Male	Female	
Femur	78	65	4.21	3.06	.0010	176	147	2.23	1.84	.0046
Acetabulum	82	77	3.80	3.17	.0080	168	147	1.70	1.39	.0005
Hip	37	40	7.86	6.45	.0383	145	127	3.97	3.17	.0001

women for the hip joint and its components in both samples.

The differences in the degree of involvement indicate that the males are utilizing the hip joint in a more stressful manner than the females in both samples or that the males are less able to cope physiologically than the females.

Cadaver studies indicate that women traditionally have more severe hip disease than men in the later years, however this sample contains none in the age groups with such a high predictability.

CHAPTER VII

THE SHOULDER JOINT

Degenerative Changes

The movement of the shoulder girdle is determined by four articulations; the sternoclavicular,the acromioclavicular, the scapulothoracic, and the glenohumeral (Inman et al. 1944). Of these four the acromioclavicular and the glenohumeral have been examined by various researchers to determine the presence of degenerative changes (Graves 1922, McKern and Stewart 1957, Jurmain 1975, Tainter 1980). The prevalence of osteoarthritis in the shoulder is generally considered to be less common than in the weight bearing joints (Steinbock 1976) and less severe (Ortner and Putschar 1981). This study is limited to the glenohumeral articulation due to the lack of extant acromion processes in the skeletal sample from Averbuch.

Lipping along the margins of the glenoid fossa progresses with age in a relatively consistent fashion (Graves 1922, McKern and Stewart 1957). The age of onset of degenerative changes differs between populations and often between sexes (Jurmain 1975). There are indications that the age of onset is correlated with functional stress

(DePalma _et al_. 1949) and the role of other culturally related activities (Goodman _et al_. 1984).

It must be realized that when we discuss the age of onset we are referring to the age at which degenerative changes may first be recognized in the bone itself either macroscopically or radiographically. A considerable amount of destruction in the cartilage and synovial tissue precedes the osseous lesion. Symptoms consisting of swelling, pain, morning stiffness, or restriction of movement may often remain unreported. A low correlation exists between clinical symptoms and radiological findings (Valkenburg 1983).

With age a diminishing range of movement ($p<.05$) bilaterally was found by Allander _et al._ (1974) in a Swedish sample, while a similar loss of range was seen in only the right shoulder of an Icelandic group. There was a strong correlation between the right and left range of motion ($p<.001$). The sample consisted of 720 individuals with an age range of 33-70 years.

The limitation of the range in motion is the result of normal aging or of degenerative joint disease in most cases (Beighton _et al._ 1973, Allander _et al._ 1974). This decrease of the normal range may occur in all joints.

Comparison of Original Variables

Five discrete areas from the glenohumeral joint were examined and scored; two from the glenoid surface and three from the humeral head. the areas are:

Humeral Head

a. HMLH - Marginal lipping on the humeral head

b. HT - Remodeling on the greater and lesser tubercles

c. HAS - Articular surface of head

Scapula

a. SMLG - Marginal lipping of the glenoid

b. SAS - Glenoid articular surface

See Appendix B for illustrations and scoring method.

For the agegroup twenties, Table 7.1 lists the probabilities of the means being the same. With the sexes combined, Averbuch has a higher mean value for all variables except the condition of the surface of the humeral head. The difference is statistically different at the highly significant rate of p=.0000 for humeral remodeling of the greater and lesser tubercles and p=.0001 for the lipping of the glenoid fossa. Humeral lipping is significant at p=.03 and the articular surface of the humeral head and the articular surface of the glenoid fossa are not significant at any level. The mean of the articular surface of the humeral head is higher in the Indian Knoll group.

TABLE 7.1

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP TWENTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HMLH	74	64	.15	.05	.0496	81	58	.23	.14	.2578	155	122	.19	.09	.0300
HT	41	60	.34	.12	.0066	61	55	.62	.27	.0002	102	115	.51	.19	.0000
HAS	77	64	.91	.97	.1519	82	57	.98	.93	.2674	159	121	.94	.95	.8010
SMLG	58	61	.71	.38	.0099	75	46	.83	.59	.0233	133	107	.77	.47	.0001
SAS	61	61	1.10	1.07	.5689	77	46	1.26	1.33	.4086	138	107	1.19	1.18	.8341

Separating the sexes, Averbuch displays a higher mean on each variable except the female humeral head surface and the glenoid fossa surface in the male sample. For the males, only the variable describing the remodeling of the tubercles is highly statistically significant at p=.0002.

The female sample displays a difference in the mean values at a significant level of p=.0099 for scapular lipping and p=.0066 for tubercle remodeling. The Averbuch sample has a higher mean except for the condition of the humeral head surface.

It appears that in the early years, ages nineteen to twenty nine, the humeral head and its opposing surface, the glenoid fossa, were being utilized in a similar fashion within both of the prehistoric skeletal series. On the contrary, the forces which contributed to osteophytic growth differed considerably between the samples.

By the time the agegroup thirties, depicted in Table 7.2, was reached the means of the samples for the lipping of the humeral head had become different enough to be significant at the p=.009 level in the combined sexes sample. The difference in the means of the remodeling of the greater and lesser tubercles is still highly significant at p=.0000. The differences between the means

TABLE 7.2

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP THIRTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
BMLH	33	81	.39	.22	.0634	35	89	.43	.26	.0659	68	170	.41	.24	.0090
HT	23	73	.70	.29	.0013	20	89	.95	.38	.0000	43	162	.81	.34	.0000
HAS	34	82	1.06	1.05	.8310	29	90	1.03	1.03	.9772	63	172	1.05	1.04	.8368
SMLG	27	65	.96	.80	.2684	32	83	1.47	1.10	.0136	59	148	1.24	.97	.0137
SAS	30	65	1.17	1.08	.1875	32	84	1.27	1.44	.0904	63	149	1.22	1.28	.3576

of the other three variables are not significant at a high statistical level. The Averbuch means are higher on all combined variables except the surface of the glenoid fossa where the Indian Knoll mean is higher.

With the sexes separated, none of the female variables are highly statistically significant at the p=.0000 level although the humeral tubercle remodeling is significant at p=.0013. The Averbuch sample displays the higher mean on each variable in the female sample. The other four variables are not statistically different.

The male sample exhibits equal means for the condition of the humeral head surface at the very non-significant level of p=.9772. The other means are higher for the Averbuch sample except for the surface of the glenoid fossa where Indian Knoll is higher at the p=.0904 level. The remodeling of the tubercles is still highly significant at p=.0000.

When examining the overforties agegroup, Table 7.3, with sexes and sides combined, only the variables for humeral lipping and remodeling are significant at the high statistical level of p=.0089 and p=.0001 level.

The means of the variables are all higher in the Averbuch sample except for the surface of the glenoid fossa which is higher for the Indian Knoll population at

TABLE 7.3

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME FOR AGEGROUP OVERFORTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
BMLH	18	15	.56	.20	.0425	19	47	.53	.28	.1043	37	62	.54	.26	.0089
HT	20	9	.95	.33	.0070	8	45	1.13	.47	.0081	28	54	1.00	.44	.0001
HAS	18	13	1.11	1.15	.7565	18	48	1.22	1.00	.0009	36	61	1.17	1.03	.0217
SMLG	16	10	1.50	1.30	.3401	13	39	1.69	1.23	.0577	29	49	1.59	1.24	.0343
SAS	17	10	1.06	1.30	.1029	13	38	1.62	1.63	.9280	30	48	1.30	1.56	.0250

the statistical level of p=.0250. The other two variables are statistically significant at the p=.0217 and p=.0343 levels. The fact that the humeral head surface difference is statistically different with the Averbuch sample having a higher mean while the opposing surface, the glenoid fossa, is also statistically different at a similar level with the Indian Knoll mean higher is noteworthy.

When the variables are separated by sex, Averbuch displays a higher mean on all variables except the condition of the female humeral head surface, the female glenoid fossa, and the male glenoid fossa, none of which are statistically significant. Remodeling of the tubercles in the female sample is significantly different at the p=.007 level, and the humeral head lipping at the p=.0425 level. In the male sample Averbuch has a higher mean on all variables except the glenoid fossa, the difference is not statistically significant (p=.9280). The condition of the surface of the humeral head is highly significant at p=.0009, the remodeling of the tubercles is significant at p=.0081.

The difference in the patterns of the sexes for the condition of the humeral head surface is striking; the female sample shows a p=.7565 probability with Indian Knoll higher and the males show a p=.0009 with Averbuch higher. Of even more interest is that the opposing surface, the glenoid fossa, has a higher mean for the Indian Knoll sample for both sexes; it would be expected that the means and probabilities would be similar for the opposing surfaces.

Table 7.4 tabulates the statistical probabilities of the means being the same for the original variables in the combined agegroup samples. The humeral variables describing lipping and remodeling exhibit higher means on the combined Averbuch sample at the highly significant levels of p=.0016 and p=.0000. The condition of the humeral head surface and the surface of the glenoid fossa display higher means in the Indian Knoll sample although not at a statistically significant level.

With the sexes separated, the Averbuch series has the higher means for the female sample except for the condition of the humeral head surface which is not statistically significant at p=.1126. The variables for lipping around the humeral head and lipping of the glenoid fossa are also statistically significant at p=.0065 and p=.0078. The difference in remodeling remains highly statistically significant at the p=.0000 level with Averbuch exhibiting a higher mean.

The Indian Knoll series also has the higher mean for the male surface of the glenoid fossa at the statistically significant level of p=.0101. Humeral

TABLE 7.4

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
WITH AGEGROUPS AND SIDES COMBINED

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
BMLH	132	160	.28	.15	.0065	141	194	.35	.23	.0565	273	354	.32	.19	.0016
BT	87	142	.56	.22	.0000	93	189	.74	.37	.0000	180	331	.66	.31	.0000
HAS	136	159	.98	1.03	.1126	135	195	1.03	.99	.2170	271	354	1.00	1.01	.8199
SMLG	106	136	.91	.65	.0078	124	168	1.09	.99	.2847	230	304	1.00	.84	.0108
SAS	113	136	1.11	1.09	.6228	127	168	1.31	1.45	.0101	240	304	1.21	1.29	.0530

tubercle remodeling remains the one variable highly significant at the p=.0000 level with the Averbuch sample exhibiting the higher mean. The other variables from the male sample are not statistically significant (p=.05).

Table 7.5 presents the probabilities of the means being the same by sex and side. One variable, the surface of the scapular glenoid fossa, shows a higher degree of involvement and a higher mean for the right side of the Indian Knoll males at the significant level of p=.0124. The left surface of the glenoid fossa also is more involved at Indian Knoll for both sexes although not at a significant level. It appears that both the males and the females of both skeletal series were utilizing areas within the shoulder joint in similar fashions.

The only consistent difference in the means at a highly significant level is in the degree of remodeling around the tubercles.

Bone and Joint Totals

The sum of the parts of the proximal humerus produced a figure for the proximal humerus, the parts of the scapula were totaled to produce a figure for the scapula. These two figures were combined to form a joint total for the shoulder. The means of these numbers were compared to determine if there was a statistical

TABLE 7.5

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE AND SEX, AGEGROUPS COMBINED

Variable	Left										Right									
	Females					Males					Females					Males				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HMLH	64	76	.31	.13	.0097	69	96	.35	.21	.1262	68	84	.25	.17	.2073	72	98	.35	.24	.2445
HT	42	67	.52	.16	.0004	41	92	.76	.37	.0001	45	75	.60	.27	.0006	52	97	.73	.37	.0001
HAS	64	75	.97	1.00	.3777	65	96	1.03	1.01	.5945	72	84	.99	1.05	.1891	70	99	1.03	.98	.2440
SMLG	56	65	.86	.60	.0526	55	89	1.00	.88	.2301	50	71	.96	.69	.0576	69	79	1.16	1.11	.9051
SAS	60	65	1.10	1.11	.9231	57	89	1.32	1.40	.2276	53	71	1.11	1.07	.4589	70	70	1.30	1.51	.0124

difference between the means of the two populations, the probabilities are shown in Table 7.6.

When combining the variables into bone and joint totals and examining them by agegroups, the three shoulder elements all show a statistically significant difference between the two populations in the third decade, the twenties. The means of the Averbuch sample are consistently higher than those of the Indian Knoll sample.

By the thirties agegroup the difference is lessening between the scapula and shoulder, although the scapula is still the only variable at a non-significant level. In the agegroup overforties there is still a statistically significant difference between the two populations concerning the deterioration of the proximal humerus. The other two categories are no longer statistically significant. With the agegroups combined the proximal humerus and shoulder are still significantly different at the p=.0000 and p=.0019 levels. Utilizing these variables and agegroups the Averbuch sample consistently has a higher mean than does the Indian Knoll sample.

In order to discuss the degree of severity and comparisons therewith, the bone and joint totals were divided into three groups describing the degree of

TABLE 7.6

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME.
BONE AND JOINT TOTALS BY AGEGROUPS
WITH SEXES AND SIDES COMBINED

Variable	Twenties					Thirties					Overforties					Ages Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
Humerus	93	115	1.56	1.23	.0002	40	156	2.35	1.62	.0000	25	53	2.60	1.77	.0008	165	324	1.93	1.51	.0000
Scap	130	107	1.98	1.64	.0015	59	148	2.47	2.26	.1097	29	48	2.90	2.77	.6330	227	303	2.23	2.12	.1168
Should	72	95	3.56	2.91	.0006	30	120	4.93	3.96	.0016	17	41	5.24	4.59	.0992	124	256	4.13	3.67	.0019

involvement; none/slight, moderate, and severe. These categories were designed to correspond as closely as possible to those depicted radiographically in the <u>Atlas of Standard Radiographs of Arthritis</u> (1963). The degree of severity was coded as follows:

Shoulder Degree of Involvement

	None/slight 1	Moderate 2	Severe 3
Proximal humerus	0-1	2-3	4-6
Scapula	0-1	2-3	4-6
Shoulder	0-2	3-6	7-9

In the following tables the degree of severity is represented numerically; i.e. none/slight is 1, moderate is 2, and severe is 3. The frequencies, Chi-square approximations, and probabilities were computed utilizing the FREQUENCY procedure (SAS Institute Inc. 1985).

Table 7.7 shows the frequency of involvement in the agegroup twenties. The scapula is more frequently and more seriously involved than the proximal humerus in both populations. There is no severe degree of change in either skeletal series in the humerus or in the combined shoulder variable at this age. The Averbuch sample exhibits a higher percentage of involvement for the three shoulder variables than does the Indian Knoll sample.

The results of this study indicating more frequent scapular involvement than proximal humeral involvement is

TABLE 7.7

SHOULDER: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP TWENTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	95	48.42	51.58	00.00	115	77.39	22.61	00.00	19.017	.000	1
Scapula	131	30.53	66.41	03.05	107	57.01	40.19	02.80	17.156	.000	2
Shoulder	74	22.97	77.03	00.00	95	47.37	52.63	00.00	10.658	.001	1

consistent with the results of other investigations (Jurmain 1975).

The Libben site in Ohio yielded a large skeletal series (n=1327) which Kelley (1979) examined for pathological lesions of degenerative joint disease. This was a fairly young group with a life expectancy at birth of 20 years. This sample of hunters and gatherers displayed a frequency of moderate to severe changes in the shoulder of 2.5%. Another sample characterized as being young was a skeletal series (n=416) from a Roman British cemetery near Dorchester, Dorset examined by Thould and Thould (1983). This sample exhibited a prevalence of 13% degenerative involvement of the shoulder. The methodology and degree of involvement were not addressed in the publication.

In another skeletal sample where the average age of death was young, Rathbun found a frequency of shoulder involvement of 13% in a metal age sample. He states that the severity can be "...attributed to physical stress and not to age alone." (Rathbun 1984:156).

In the agegroup thirties, Table 7.8, the scapula remains more involved than the proximal humerus at both the moderate and severe levels in both samples; the Indian Knoll sample exhibits more severe scapular lesions than does Averbuch. In the shoulder as a whole, Indian Knoll

TABLE 7.8

SHOULDER: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP THIRTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	40	22.50	70.00	07.50	156	56.41	42.31	01.28	17.313	.000	2
Scapula	59	08.47	79.66	11.86	148	19.59	66.89	13.51	4.239	.120	2
Shoulder	30	10.00	80.00	10.00	120	10.83	83.33	05.83	0.673	.714	2

exhibits more moderate changes and Averbuch more severe ones.

The scapula remains the more frequently and severely involved element in the agegroup overforties in Table 7.9. The Averbuch series exhibits a 100% involvement at the moderate and severe degree. The Indian Knoll sample exhibits a 27.08% severe involvement to the Averbuch's 20.69% while the Averbuch sample is more frequently involved at the moderate level, 79.31% to Indian Knoll's 66.67%.

Both the scapula and combined shoulder are 100% involved in the Averbuch series at this age. These results are consistent with those of Martin et al. (1979) who found that in a combined sample from Dickson Mounds 100% of the individuals displayed scapulae affected by degenerative changes by age 55.

The degree of involvement of degenerative changes within the shoulder joint and the degree of changes on the individual bones with the agegroups combined are tabulated in Table 7.10. When examining the percentages it is obvious that the scapula is involved more frequently as well as more severely than the humerus in both samples. More severe changes are exhibited in the Indian Knoll sample both in the scapula and in the shoulder than the

TABLE 7.9

SHOULDER: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP OVERFORTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	25	16.00	72.00	12.00	53	41.51	58.49	00.00	10.170	.006	2
Scapula	29	00.00	79.31	20.69	48	06.25	66.67	27.08	2.517	.284	2
Shoulder	17	00.00	88.24	11.76	41	07.32	82.93	09.76	1.331	.514	2

TABLE 7.10

SHOULDER: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS WITH AGEGROUPS, SEXES,
AND SIDES COMBINED

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	160	36.88	59.38	03.75	324	61.42	37.96	00.62	29.367	.000	2
Scapula	219	20.55	71.69	07.76	303	30.69	57.43	11.88	11.152	.004	2
Shoulder	121	16.53	79.34	04.13	256	23.83	71.88	04.30	2.659	.265	2

Averbuch sample. The Averbuch series is consistently more frequently involved for all variables over all.

Jurmain (1975) found that the scapula was involved more than the humerus in the four population samples which he analyzed, both the modern ones from the Terry collection and the archaeological ones, although the modern groups both had a higher degree of degeneration on both elements. As he states, the probable cause for the increased involvement is the increased longevity of the modern groups.

In contrast to Jurmain's (1975) results, Kilgore (1984) found that the proximal humerus was more involved than the scapula in a population of Medieval Nubians.

Gejvall (1983) found that the degenerative changes in the shoulder were mostly confined to the humeral head although the glenoid fossa exhibited some changes. The cemetery at Vasterhus where the sample was excavated dated from the early medieval period in Sweden.

Pfeiffer's (1977) examination of a North American Great Lakes Indian group showed an increase in scapular involvement compared to the proximal humerus.

In the present study the scapula is consistently more involved than the humerus in both populations both with the sexes together and with them separated.

In Table 7.11, a comparison of the frequency of

TABLE 7.11

SHOULDER: COMPARISON OF FREQUENCIES OF BONE TOTALS
BY SEX. AGEGROUPS AND SIDES COMBINED

Female

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	79	45.57	49.37	05.06	142	69.72	30.28	00.00	17.019	.000	2
Scapula	101	26.73	68.32	04.95	136	41.18	56.62	02.21	6.034	.049	2
Shoulder	57	24.56	68.42	07.02	110	35.45	63.64	00.91	6.215	.045	2

Male

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	81	28.40	69.14	02.47	182	54.95	43.96	01.10	16.013	.000	2
Scapula	118	15.25	74.58	10.17	167	22.16	58.08	19.76	8.632	.013	2
Shoulder	64	09.38	89.06	01.56	146	15.07	78.08	06.85	4.115	.128	2

involvement by sex, the males consistently display more frequent involvement for all variables. The male sample also has a more severe degree of degenerative changes for the variables except for the proximal humerus in the Averbuch sample. The females exhibit a 5.6% severe involvement to the males' 2.47%.

Tainter (1980) examined the shoulder joints of a Middle Woodland mortuary population to determine the difference in the degree of degenerative disease between samples of presumably high status and presumably low status individuals. Two of the three variables utilized in his work were the humeral head and the glenoid fossa. To compensate for the normal increase of involvement with progression with age, he limited his study to individuals of over 35 years. His results showed that high ranking females displayed a .429 proportion and the lower ranking ones a .537 proportion of high involvement while the males had .584 proportion of heavy involvement for the higher rank and .643 for the lower one.

Bovenzi et al. (1980) examined a group of Italian shipyard caulkers who had been exposed to arm-hand vibration for an average of ten years, the mean age of the group was 41.5 years. Their investigations revealed a 20.1% prevalence rate of radiological lesions in the right shoulder joint. No radiological survey was implemented for the control group. The complaint rate differed greatly though, 79.9% of the caulkers and 8.3% of the controls complained of shoulder arthralgia.

Bennike (1985) found no differences between the sides or between the agegroups and combined them to obtain frequencies for three Danish skeletal series. With the sexes also combined, she shows a decrease in degenerative changes from the Neolithic period, 4.9%, through the Iron Age, 3.2%, and into the Middle Ages, 1.8%. The Neolithic men exhibited the highest rate of degenerative changes in the shoulder; only one female in the complete sample exhibited degenerative lesions, she was from the Iron Age sample (n=3 females). Bennike utilized the presence of osteophytes as the single criterion for degenerative disease in the joints.

Examining the current data by side in an attempt to determine a pattern of involvement, Table 7.12 shows that the right side is consistently more involved at the combined moderate/severe level for all variables. Averbuch has a higher frequency of severe changes in both sides of the proximal humerus and shoulder while Indian Knoll has a higher rate of severe degenerative changes in both scapulae.

Larsen (1980, 1984), in comparing a pre-agricultural group to an agricultural group in a

TABLE 7.12

SHOULDER: FREQUENCY OF INVOLVEMENT BY SIDE

Left

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	78	39.74	57.69	02.56	157	63.69	35.03	01.27	12.160	.002	2
Scapula	106	21.70	72.64	05.66	154	31.17	60.39	08.44	4.168	.124	2
Shoulder	57	21.05	75.44	03.51	128	25.78	71.09	03.13	0.483	.785	2

Right

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	82	34.15	60.98	04.88	167	59.28	40.72	00.00	19.721	.000	2
Scapula	113	19.47	70.80	09.73	149	30.20	54.36	15.44	7.329	.026	2
Shoulder	64	12.50	82.81	04.69	128	21.88	72.66	05.47	2.629	.269	2

prehistoric Georgia coast sample, found a decrease in degenerative involvement in the shoulder joint in the agricultural sample with sexes combined. The frequency declined from 4% to 1%, this was not statistically significant. However when the sexes were separated, the male frequency decreased from 10.5% to 1.7%.

Rogers et al. (1981) described pathological lesions in an archaeological series of individuals from the west of England. In a series with the ages and sexes combined, the results showed a higher frequency of advanced degenerative changes in the shoulder joint in a Saxon series (ninth to eleventh centuries) than in a medieval series (thirteenth to fifteenth centuries) 24% to 12%. The individuals are characterized as being rather young, encompassing a 20-50 year age range with a probable mean of 40 years. It is not known what occupation or activities of the Saxon group may have contributed to the high frequency or if another aetiological factor may have had an important influence.

Averbuch generally exhibits higher means on the variables when dividing the sexes and combining the agegroups and sides, Table 7.13. Only the male scapula exhibits a higher mean for Indian Knoll; it and the male shoulder variable are not statistically significantly

TABLE 7.13

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
BY SEX

Variable	Female					Male				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Humerus	81	142	1.86	1.38	.0003	84	182	2.00	1.60	.0002
Scapula	105	136	2.03	1.74	.0084	122	167	2.41	2.44	.7843
Shoulder	59	110	3.83	3.07	.0019	65	146	4.40	4.12	.1155

different. The female variables are all statistically different at varying levels of significance.

The differences of the means of the variables of the two populations produce the following probabilities when comparing the samples by side, Table 7.14. The greatest difference lies in the means of the proximal humerus. These are significant at the p=.0002 level for the left side and p=.0008 level for the right.

Very few osteological studies have described the symmetry or asymmetry of degenerative involvement within the shoulder joint. Jurmain (1975), in his very complete thesis on degenerative joint disease, tabulated the results of his observations from the four populations he studied and compared them with the results of a study of cadavers undertaken by Heine in 1926.*

The symmetry of degree of right-left involvement of the shoulder joint was examined in this current report to determine if a pattern of involvement might emerge which would assist in making a statement concerning cultural activities involving these two archaeological groups. The symmetry is relatively consistent between the two populations. The females of each group exhibit 85% symmetry in the degree of involvement. The males are more

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* the bibliographic citation taken from Jurmain (1975) is
Heine, J. "Uber die Arthritis Deformans".
1926 Virchow's Arch. Path. Anat. 260:521-663.

TABLE 7.14

SHOULDER: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE

Variable	Left					Right				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Humerus	78	157	1.92	1.46	.0002	87	167	1.94	1.55	.0008
Scapula	109	154	2.15	2.04	.2442	118	149	2.31	2.21	.3373
Shoulder	57	128	4.05	3.53	.0188	67	128	4.19	3.80	.0562

symmetrical with the Averbuch males showing 88% symmetry while the Indian Knoll sample shows 91.2% affected equally on both sides.

These figures compare relatively well with Jurmain's (1975) results of 82.5% displaying symmetry in his combined sample. The asymmetry displayed among the females at Averbuch show involvement between slight/moderate for 5% (one individual) and 10% (2 individuals) for moderate/severe. There was a 12.5% incidence of asymmetry with the slight/moderate group of Indian Knoll females and .02% moderate/severe (one individual). The disparity between the moderate/severe groups may well be a result of the small sample size from Averbuch. No individual in either group displayed asymmetry to the extent of slight/severe.

Among the Averbuch sample with the sexes combined, 86.8% showed symmetrical involvement; 10.5% displayed asymmetry with the right involvement greater than left, and 2.65% had asymmetry with the left greater than the right. The Indian Knoll results were similar with 88.5% of the total showing symmetrical involvement; 9.5% exhibited greater involvement on the right side than on the left, and 1.9% displayed greater left involvement than right.

In examining the samples from each population separately, no statistical difference was found when comparing the means of the sides to determine if one side exhibited more extensive wear patterns. Table 7.15 presents the probabilities.

In this study a consistent degree of heavier shoulder involvement among the males than the females of both populations is found. The means are consistently higher for the males, Table 7.16. The difference in the means of the proximal humerus in the Averbuch sample is not statistically significant (p=.1776); nor is that of the shoulder at Averbuch highly significant (p=.0190).

Kelley (1980), when examining three samples from prehistoric American Indian sites, found that the males exhibited higher rates of osteoarthritis in all joints. The skeletal series discussed by him were Indian Knoll, Mobridge, and Grasshopper. The hunter-horticulturalists from Mobridge displayed the highest frequencies of shoulder involvement.

Males also displayed a higher frequency and a greater severity of degenerative changes in the shoulder joint in an investigation of the Sadlermiut Eskimos (Merbs 1983).

In contrast, Kilgore (1984) found significant differences between the females and males of the Nubian population (A. D. 550-1450) with the females displaying a

TABLE 7.15

SHOULDER: PROBABILITIES OF THE MEANS OF THE SIDES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Left	Right	Left	Right		Left	Right	Left	Right	
Humerus	78	87	1.92	1.94	.9357	157	167	1.46	1.55	.2880
Scapula	109	118	2.15	2.31	.2099	154	149	2.04	2.21	.2077
Shoulder	57	67	4.05	4.19	.7031	128	128	3.53	3.80	.1470

TABLE 7.16

SHOULDER: PROBABILITIES OF THE MEANS OF THE SEXES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch					Indian Knoll				
	N		Mean		Prob	N		Mean		Prob
	Male	Female	Male	Female		Male	Female	Male	Female	
Humerus	84	81	2.00	1.86	.1776	182	142	1.60	1.38	.0064
Scapula	122	105	2.41	2.03	.0009	167	136	2.44	1.74	.0000
Shoulder	65	59	4.40	3.83	.0190	146	110	4.12	3.07	.0000

68.9% involvement of right-sided lesions with 48.1% involvement in males. This was statistically significant (p=0.03).

Another example of females exhibiting a higher frequency of shoulder change in contrast to males is in the monastic cemetery at Jarrow in northern England (Cramp 1983). No frequencies figures are presented nor were the occupations of those interred in the cemetery known.

Angel (1971) discussed an example of shoulder arthritis, the only one found in his study of a prehistoric Aegean population, and suggested the probable cause as her occupation as a weaver. No involvement was exhibited among the males of the sample.

Pfeiffer (1977) found that males had a higher degree of involvement of the scapula on the right while females showed more involvement on the left, this was not statistically significant.

CHAPTER VIII

THE ELBOW JOINT

Degenerative Changes

The elbow is a complex joint comprised of three bones; the humerus, ulna, and radius, and three distinct articulations; the humeroradial, the radioulnar, and the humeroulnar. The entire joint is encapsulated by ligaments lined with the synovial membrane. Three different kinds of reciprocal action occur at the articulations, flexion and extension at the humeroulnar, pronation and supination at the the radioulnar and humeroradial, and abduction and adduction at the humeroulnar (Shipman et al. 1985).

Goodfellow and Bullough (1967) examined a sample of twenty eight elbow joints from necropsy subjects to determine a pattern of age-related changes in the articular cartilage of the elbow. The rim of the radial head and the articular surface of the capitulum expressed mirror images of each other in the pattern of involvement. The authors hypothesized that the consistent pattern which was revealed implies a mechanical explanation.

Osteoarthritis is relatively uncommon in the elbow although it may be induced by repeated minor insults of occupational utilization (Katz 1977). Theoretically a study of the pattern of involvement of degenerative changes in the elbow could elucidate the characteristic movements of the arm within a specific population and assist in identifying occupational factors in archaeological samples and forensic cases (Ortner 1968, Kennedy 1983). The pattern of degeneration in the elbow follows that of the other joints: insult to the cartilage including flaking and tearing; pitting, porosity, sclerosis, osteophytic growth, and eburnation of the underlying bone. The osseous changes are secondary to the cartilage deterioration and only occur after a considerable degree of cartilaginous destruction. Degenerative changes upon the bone itself represent an advanced state of the pathological entity.

Osteophytes in the elbow are not as age-related as in the other joints (Jurmain 1975) and appear to be linked with a strong mixed-rotary movement (Jurmain 1978). The exuberant development may be viewed as a response to abnormal patterns of movement within the joint (Miller 1985).

Symptoms associated with degenerative joint disease of the elbow include tenderness upon pressure, pain on extension, loss of pronation and supination range, and a decrease in terminal extension.

Comparison of Original Variables

Fourteen individual variables were examined in the elbow joint; six on the distal humerus, six on the ulna and two on the radius. They were scored for porosity, pitting, osteophytic growth and eburnation. The areas are:

Distal Humerus

a. HTMM - Trochlea medial margin

b. HLTR - Lateral trochlear ridge

c. HOF - Olecranon fossa

d. HCF - Coronoid fossa

e. HAST - Trochlea articular surface

f. HASC - Capitulum articular surface

Ulna

a. UCML - Coronoid process marginal lipping

b. UOML - Olecranon process marginal lipping

c. URML - Radial facet lipping

d. UASC - Coronoid process articular surface

e. UA - Olecranon process articular lipping

f. UASR - Radial facet articular surface

Radius

a. RSSH - Superior surface of head

b. RIMH - Inferior surface of head

See Appendix B for illustrations and scoring methodology.

The individuals were controlled for age and each agegroup analyzed separately. The scored mean of the variables shows a definite progression with age; the means of both the original variables and the bone and joint totals rise with each age level.

Probabilities of Original Variables

In the agegroup twenties, Table 8.1, with the sexes combined, the Averbuch sample shows a higher mean for each variable. On the distal humerus two variables describing the fossae and the one describing the trochlea medial margin are significantly statistically different at the p=.0000 level. The least significant difference is with the surface of the trochlea (p=.0862). On the ulna the variables describing lipping are statistically different at the p=.0000 level, while the ones concerning the surfaces are not statistically different (p=.01). The superior articular surface of the radius shows no statistical difference (p=.3367); the inferior surface difference is significant at the p=.0000 level.

Examining Table 8.1 with the sexes separated, the Averbuch sample consistently shows the higher mean. On the humerus the female sample displays a high statistical difference on the trochlea medial margin and the fossae.

The areas on the ulna describing lipping for the female sample are all highly significant at the p=.0000 or p=.0004 level. The radial inferior surface is highly

TABLE 8.1

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP TWENTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob.	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HTMH	57	66	.49	.03	.0000	69	60	.45	.00	.0000	126	126	.47	.02	.0000
HLTR	75	66	.81	.68	.1216	87	61	.85	.64	.0175	162	127	.83	.66	.0050
BOF	81	66	.35	.02	.0000	88	61	.40	.07	.0000	169	127	.37	.04	.0000
BCF	81	66	.47	.17	.0002	87	61	.48	.28	.0170	168	127	.48	.22	.0000
HAST	79	66	.96	.88	.1739	83	61	.94	.89	.2902	162	127	.95	.88	.0862
HASC	70	66	.94	.88	.3516	61	75	.95	.84	.0524	145	127	.94	.86	.0482
UCML	62	62	.69	.15	.0000	70	54	.80	.19	.0000	132	116	.75	.16	.0000
UOML	60	62	.80	.15	.0000	66	54	.83	.13	.0000	126	116	.82	.14	.0000
URML	63	62	.25	.03	.0004	58	55	.43	.00	.0000	121	117	.34	.02	.0000
UASC	67	63	.91	.87	.5421	79	55	1.08	.96	.0188	146	118	1.00	.92	.0305
UA	66	63	.95	.89	.2148	74	55	1.03	.96	.1014	140	118	.99	.92	.0361
UASR	67	63	.91	.83	.1533	74	55	.95	.84	.0421	141	118	.93	.83	.0138
RSSH	62	60	.97	.93	.6937	65	57	1.00	1.05	.2791	127	117	1.01	.97	.3367
RIMH	45	59	.93	.29	.0000	48	57	.77	.32	.0000	93	116	.85	.30	.0000

significant at p=.0000 while the means of the superior surface are not statistically different (p=.6937).

The male sample exhibits results similar to those of the female sample on all elements; the primary differences are that two humeral variables, the lateral trochlea ridge and the coronoid fossa are close to being significantly different at the p=.01 level.

Table 8.2 enumerates the statistical probabilities of the means of the variables being the same in the second agegroup, the thirties. There is a remarkable similarity between the figures in Table 8.1 and those of Table 8.2. However, in the agegroup twenties the Averbuch sample consistently had the higher means for all variables. By the agegroup thirties with the sexes combined, the ulnar variable describing the radial facet surface has equal means for both prehistoric populations. The humeral variable describing the trochlea medial margin and the two describing the fossae are still highly statistically different (p=.0000); the lateral trochlea ridge is now at the p=.0051 level.

The same ulnar variables which were highly statistically significant in the agegroup twenties are still at the same level in the thirties agegroup. The superior surface of the radius is now statistically significant at the p=.002 level.

TABLE 8.2

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP THIRTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
RTMM	32	89	.69	.09	.0000	22	100	.73	.08	.0000	54	189	.70	.08	.0000
RTLR	41	92	1.15	1.00	.2796	36	101	1.17	.78	.0057	77	193	1.16	.89	.0051
ROF	40	92	.50	.11	.0000	33	101	.64	.13	.0000	73	193	.56	.12	.0000
RCF	39	92	.64	.34	.0025	32	101	.78	.29	.0000	71	193	.70	.31	.0000
RAST	38	91	1.05	.98	.1238	34	101	.91	.95	.4441	72	192	.99	.96	.5452
RASC	37	92	1.08	.96	.0064	30	100	.97	.99	.8055	67	192	1.03	.97	.1089
UCML	34	86	1.15	.24	.0000	25	96	1.28	.47	.0000	59	182	1.20	.36	.0000
UOML	31	85	1.13	.32	.0000	25	98	1.40	.47	.0000	56	183	1.25	.40	.0000
URML	35	85	.46	.14	.0006	26	98	.65	.20	.0000	61	183	.54	.17	.0000
UASC	35	87	1.03	1.09	.3047	27	98	1.15	1.04	.0750	62	185	1.08	1.06	.7365
UR	33	87	1.03	1.02	.8719	27	98	1.07	1.01	.1424	60	185	1.05	1.02	.2604
UASR	36	86	.92	.98	.1305	29	98	1.00	.93	.1920	65	185	.95	.95	.9300
RSSH	29	83	1.17	1.00	.0534	31	88	1.16	1.00	.0164	60	171	1.17	1.00	.0020
RIMH	25	81	1.20	.86	.0104	25	82	1.12	.59	.0001	50	163	1.16	.72	.0000

With the sexes separated, two female humeral variables are still highly significant at the p=.0000 level, the trochlea medial margin and the olecranon fossa. The coronoid fossa is statistically different at the p=.0025 level. The capitulum surface now shows a statistical difference (p=.0064).

In the female sample two ulnar variables show a higher mean in the Indian Knoll sample than in the Averbuch; these are the surfaces of the coronoid and the radial facet; they are not statistically significant at the p=.01 level. The three variables describing osteophytic growth are highly significant at p=.0000 and p=.0006. The radial superior surface is not statistically different at p=.0534 while the inferior surface is marginally different (p=.0104).

In the male sample, the articular surfaces of the trochlea and the capitulum show a higher mean for the Indian Knoll sample than in the Averbuch one although not at statistically significant levels. The humeral variables describing the trochlea medial margin and the two fossae are still highly significantly different (p=.0000). The three ulnar variables describing lipping are also at the same high level of p=.0000. The radial superior surface is not statistically significantly different at p=.0164 while the inferior surface is highly significant at p=.0001.

It would appear that the males of both samples are utilizing the humeral surfaces in a similar fashion and the females utilizing the ulnar surfaces in a comparable way.

In the overforties agegroup, Table 8.3, with the sexes combined over half the variables in the elbow exhibit a statistical significance at the p=.005 level. On the humerus the trochlea medial margin and the olecranon fossa remain highly statistically significant in the differences in the means between the two population samples. The coronoid fossa and the trochlea surface are also significant at other levels (p=.0009 and p=.0032). Of the ulnar variables describing lipping the coronoid and olecranon variables are still highly significant at the p=.0000 level. The radial facet lipping is also highly significant at p=.0018. The radial facet surface exhibits a higher mean for the Indian Knoll sample although not at a statistically significant level (p=.1171). The radial head superior surface is significantly different at p=.0032, while the inferior surface is not significant p=.4994).

The females show fewer differences between the population samples than the sexes combined sample in the

TABLE 8.3

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME
FOR AGEGROUP OVERFORTIES

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HTMM	13	17	.77	.00	.0003	14	48	1.00	.10	.0000	27	65	.89	.08	.0000
HLTR	18	18	1.33	1.22	.6713	20	49	1.50	1.35	.3115	38	67	1.42	1.31	.4190
HOF	17	17	.65	.12	.0019	20	48	.80	.25	.0000	37	65	.73	.22	.0000
HCF	16	18	.75	.56	.2519	20	49	1.00	.51	.0009	36	67	.89	.52	.0009
HAST	16	18	1.06	1.00	.3165	21	49	1.24	1.00	.0026	37	67	1.16	1.00	.0032
HASC	14	18	1.29	1.00	.0465	19	49	1.11	1.06	.5770	33	67	1.18	1.04	.0894
UCML	11	17	1.18	.35	.0047	14	45	1.43	.60	.0000	62	25	1.32	.53	.0000
UOML	12	17	1.25	.29	.0017	14	46	1.50	.63	.0000	26	63	1.38	.54	.0000
URML	11	17	.91	.24	.0027	14	48	.79	.52	.0807	25	65	.84	.45	.0018
UASC	14	17	1.14	1.06	.4617	16	46	1.25	1.07	.0476	30	63	1.20	1.06	.0491
UA	15	17	1.20	1.00	.0616	17	47	1.00	1.11	.1697	32	64	1.09	1.08	.8013
UASR	14	16	1.00	1.13	.1942	16	47	1.00	1.06	.3145	30	63	1.00	1.08	.1171
RSSH	13	16	1.23	1.13	.4818	12	41	1.50	1.05	.0010	25	57	1.36	1.07	.0032
RIMH	10	15	.90	1.00	.5778	10	40	1.00	.77	.3016	20	55	.95	.84	.4994

overforties agegroup in the pattern of degenerative changes in the elbow. Those variables which do exhibit a statistical difference apply to osteophytic growth either on the margins of the bone or within the olecranon fossa. In general the Averbuch female sample still has a higher mean for the variables although the difference is only statistically significant in the lipping variables on the ulna ($p > .005$) and two variables in the humerus ($p=.0003$ and $p=.0019$).

One ulnar variable, the radial facet and its opposing articular surface on the radius, the inferior margin of the head, show a higher mean for Indian Knoll than Averbuch; neither difference is statistically significant.

In the male sample the Averbuch means are higher for all variables except for the ulnar radial facet and the olecranon surface; these are not statistically different ($p=.3145$ and $p=.1697$). As a whole, the males also display a more statistically significant difference between the means of the two samples than the females. Four variables, all representing areas which may develop osteophytic lipping, are very highly statistically significant at the $p=.0000$ level. The means of the coronoid fossa, the trochlea surface, and the radial head superior surface are all statistically significant at different levels (p=.0009, p=.0026, p=.0010).

In Table 8.4, the combined agegroups, with the sexes combined a greater degree of involvement in the Averbuch sample is indicated by a higher mean on each variable. The humeral articular surfaces of the trochlea and capitulum, lipping on the trochlea ridge, and the articular surfaces of the ulna are the only variables of the fourteen elbow variables whose means are not statistically significant at some level (p=.01).

For the female sample, the mean of each variable is higher for the Averbuch sample with the exception of two areas on the ulna, the coronoid articular surface and the articular surface for the radial facet; neither is statistically significant (p=.4427 and p=.6847). None of the articular surfaces on the humerus or ulna show a significant degree of difference in the degenerative wear patterns between the two populations. The variables describing lipping on the ulna and the humeral fossae and trochlea medial margin are highly statistically significant at the p=.0000 level. The inferior surface of the radial head shows the same statistical probability.

There are some apparent differences between the sexes in the pattern of involvement, particularly on the

TABLE 8.4

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME WITH AGEGROUPS AND SIDES COMBINED

Variable	Females					Males					Sexes Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HTMM	104	172	.60	.06	.0000	110	208	.59	.06	.0000	214	380	.59	.06	.0000
HLTR	140	176	.97	.90	.3137	150	211	1.03	.87	.0263	290	387	1.00	.89	.0197
HOF	145	175	.42	.07	.0000	148	210	.53	.14	.0000	293	385	.47	.11	.0000
HCF	143	176	.53	.30	.0000	146	211	.64	.34	.0000	289	387	.58	.32	.0000
HAST	139	175	.99	.94	.1532	145	211	.99	.94	.2077	284	386	.99	.94	.0570
HASC	125	176	1.02	.93	.0473	130	210	.98	.96	.4580	255	386	1.00	.95	.0570
UCML	113	165	.89	.22	.0000	116	195	1.03	.42	.0000	229	360	.97	.33	.0000
UOML	106	164	.95	.25	.0000	111	198	1.09	.41	.0000	217	362	1.02	.34	.0000
URML	112	164	.38	.11	.0000	105	201	.56	.22	.0000	217	365	.47	.17	.0000
UASC	121	167	.98	1.01	.4427	129	199	1.12	1.03	.0047	250	366	1.05	1.02	.2121
UA	120	167	1.00	.97	.3592	125	200	1.04	1.02	.4428	245	367	1.02	1.00	.2603
UASR	123	165	.92	.93	.6847	126	200	.95	.93	.5603	249	365	.94	.93	.9117
RSSH	108	159	1.06	.99	.1841	112	186	1.14	1.01	.0006	220	345	1.10	1.00	.0012
RIMH	80	155	1.01	.66	.0000	87	179	.93	.54	.0000	167	334	.97	.60	.0000

lateral trochlea ridge, the surface of the capitulum and the coronoid articular surface.

The males of both samples exhibit more similar wear on the humeral articular surfaces, and the females show more similar patterns on the ulnar surface. Both surfaces of the radial head are highly statistically significant in the male sample (p=.0006 and p=.0000).

Separating the data by sex and sides, Table 8.5 tabulates the probabilities of the means of the samples being the same. Fewer differences exist in the pattern of degenerative joint disease between the Averbuch and Indian Knoll variables describing the elbow and shoulder than between the variables of the lower limbs. For the female sample the Averbuch individuals show a higher mean on all elbow variables except the left trochlear ridge, the right olecranon surface, the right coronoid surface and both right and left radial facet surfaces; the means are equal for the two population samples for the left coronoid surface. None of these differences are statistically significant.

There are variables for the female sample with highly significant statistical differences at the p=.0000 level for both left and right sides; they are the trochlea medial margins, the olecranon fossae, coronoid and olecranon lipping, and the inferior surface of the

TABLE 8.5

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME
BY SIDE AND SEX, AGEGROUPS COMBINED

Variable	Left										Right									
	Females					Males					Females					Males				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
HTMM	51	85	.59	.04	.0000	53	104	.55	.01	.0000	53	87	.60	.08	.0000	57	104	.63	.12	.0000
HLTR	66	87	.86	.87	.9851	72	105	1.00	.82	.0865	74	89	1.07	.93	.1612	78	106	1.05	.92	.1643
HOF	70	87	.36	.05	.0000	74	104	.47	.13	.0000	75	88	.48	.10	.0000	74	106	.58	.15	.0000
HCF	69	87	.53	.26	.0016	74	105	.58	.30	.0002	74	89	.54	.33	.0084	172	106	.69	.38	.0001
HAST	68	87	.99	.94	.4260	69	105	.96	.95	.9584	71	88	1.00	.96	.2163	76	106	1.01	.93	.0977
HASC	64	87	1.03	.93	.1362	61	104	.92	.93	.7293	61	89	1.00	.93	.1959	69	106	.04	.99	.2534
UCML	49	84	.96	.23	.0000	59	97	.98	.37	.0000	64	81	.84	.21	.0000	57	98	1.09	.47	.0000
UOML	46	84	.98	.25	.0000	55	98	1.09	.38	.0000	60	80	.93	.25	.0000	56	100	1.09	.45	.0000
URML	50	83	.38	.11	.0005	50	100	.52	.19	.0000	62	81	.39	.11	.0002	55	101	.60	.26	.0000
UASC	54	84	.98	.98	.9360	65	99	1.09	1.01	.0634	67	83	.97	1.04	.2049	64	100	1.14	1.04	.0324
UA	54	84	1.02	.95	.1839	61	99	1.05	1.00	.1506	66	83	.98	.99	.9438	64	101	1.03	1.04	.8366
UASR	55	85	.91	.93	.7199	61	100	.93	.93	.9118	68	81	.93	.94	.8115	65	100	.97	.94	.5008
RSSH	50	78	1.08	.99	.3889	50	94	1.12	1.00	.0244	58	81	1.05	.99	.3182	62	92	1.16	1.02	.0111
RIMH	38	76	1.03	.67	.0000	40	90	.90	.53	.0000	42	79	1.00	.65	.0000	47	89	.96	.55	.0000

radial head. The coronoid fossa and radial facet lipping are also statistically significant at a high level. There is a noteworthy consistency of probabilities between the sides for the females.

For the male sample, the Indian Knoll individuals exhibit a higher mean on only the left capitulum surface and the right olecranon surface; the means of the samples are equal for the left radial facet surface.

The same variables which have differences of a highly statistically significant nature in the female sample (p=.0000) repeat that probability in the male sample; the female samples concerning the radial facet lipping join the males (p=.0000) with probabilities of extremely high significance (p=.0002, p=.0005).

Frequencies of Original Variables

There is a body of data compiled by other investigators utilizing specific areas within the elbow joint. In order to discuss these comparative studies adequately and to provide the data in a usable form for future researchers, the frequency of involvement of the original elbow variables were determined utilizing the FREQ software package produced by SAS Institute Inc. (1985).

Tables 8.17 through 8.20 located in Appendix C, tabulate the frequencies by sex, with the sexes combined, by side, and by sex and side. The original variables were scored independently, each with a criterion specific for that particular surface. Appendix B illustrates the scoring method.

For the combined sample, Table 8.17 located in Appendix C, page 311, the humeral area most often involved is the trochlea articular surface in both the Averbuch and Indian Knoll samples; 93.77% in Averbuch and 93.27% in the Indian Knoll sample. The surface of the capitulum was the most severely involved with each sample showing a slight degree of severe involvement: .41% Averbuch and .26% Indian Knoll. This is the only humeral variable with any severe degree of involvement. The lateral trochlear ridge exhibits the greatest degree of moderate involvement on the humerus with 17.56% of the Averbuch sample and 18.6% of the Indian Knoll sample falling in this category.

Marginal lipping along the coronoid process is the ulnar variable with the highest frequency of moderate involvement in the Averbuch sample, 20.37%. The surface of the coronoid process is the most seriously involved ulnar variable at Indian Knoll, 5.19%. The olecranon surface of the ulna is almost universally involved at the slight and moderate level in both samples; 97.84% in Averbuch, 97% in Indian Knoll; the coronoid surface is similarly affected with 96.64% at Averbuch and 96.45% at Indian Knoll. Lipping on the margins of the olecranon is more intensely involved than the surface with 3.37% severe involvement at Averbuch and .55% at Indian Knoll. The superior surface of the radial head for the Averbuch sample displays a .94% involvement at the two severe grades for that variable; there is no severe involvement in the Indian Knoll sample although there is more total involvement with Indian Knoll.

Table 8.18 located in Appendix C, page 312, presents the frequencies of involvement for the sexes separately; some interesting patterns emerge. For the Averbuch sample, the females consistently display the higher involvement of severe involvement on the elbow variables. On the humerus there are four of the six variables where the females exhibit more slight/moderate involvement as well. In the Indian Knoll sample, only one humeral variable, the lateral trochlea ridge, exhibits more involvement for the female sample at the slight/moderate level than does the male, 77.72% to 67.77%.

The ulna presents a different pattern with the males of the Averbuch sample consistently displaying more involvement at the slight/moderate stages than the females; the females display more moderate involvement for four of the six variables. One ulnar variable, the radial facet surface, shows slightly more total involvement for the Indian Knoll females than the males, 92.12% to 91.5%.

The radial variables show more total male involvement for the superior surface of the radial head, although the Averbuch female sample has slightly more severe involvement than the Averbuch males; .95% to .93%. The female samples of both the Averbuch and Indian Knoll groups display more slight and more moderate involvement of the inferior surface than the male sample.

Comparing the females of Averbuch with those of Indian Knoll, only two elbow variables show more involvement for Indian Knoll than for Averbuch, the surface of the coronoid process and the superior surface of the radial head. The surface of the coronoid process displays more moderate wear for the Indian Knoll sample, 6.59% to 3.45% for Averbuch.

Among the males, Averbuch exhibits more involvement on all but three elbow variables, the humeral trochlea surface, the surface of the capitulum, and the superior surface of the radial head.

Table 8.19 located in Appendix C, page 314, presents the frequencies of involvement by side. In examining the frequencies on the left side, Averbuch exhibits more involvement than Indian Knoll with the exceptions of the humeral trochlea surface and the superior surface of the head of the radius. The increase in involvement in both these variables is found in the slight rating, 92.71% to 87.31% and 94.77% to 80.81%.

For the right side, again Averbuch is fairly consistent in having higher frequencies than does Indian Knoll. The two exceptions are the surface of the olecranon process and the superior surface of the head of the radius. The olecranon process shows more moderate involvement at Indian Knoll, 3.8%, than at Averbuch, 3.31%, and the radial head more slight involvement at Indian Knoll 95.95% than Averbuch, 78.95%.

Table 8.20 located in Appendix C, page 316, presents the frequencies by sex and side. There is a certain amount of consistency among the frequencies by sex and side. Averbuch is more involved in all subgroups for all variables with few exceptions. Indian Knoll consistently shows a higher frequency of involvement for the superior surface of the head of the radius. The females of Indian Knoll have a slightly higher involvement, both right and left, for the surface of the coronoid process. The males of Indian Knoll show a greater involvement on the left for the trochlea and capitulum surfaces; for the right side a greater involvement for the surface of the coronoid process.

It is interesting that the capitulum is the only humeral area which exhibits a severe degree of degenerative lesions. The radial head and the center of the capitulum are small areas of contact where the greatest amount of stress occurs during both pronation/supination and flexion/extension (Ortner 1968). The rim of the head of the radius and the capitulum are in contact only with full extension of the arm.

This radiohumeral articulation is the site of severe degenerative changes in individuals from many different population samples. The patterns of involvement of the radiohumeral articulation in the Sadlermiut Eskimos differed between the sexes with the male having a higher degree of involvement on the radiohumeral articulation while the females had more involvement on the humeroulnar articulation (Merbs 1983). The degenerative changes in the humeroradial articulation were quite severe in the Eskimo sample described by Jurmain (1978).

The results of the investigation of Eskimos and Aleuts undertaken by Laughlin (1963) showed that the capitular surface of the humerus had the highest frequency of arthritic lesions among the males while the trochlear surface, which is a component of the ulnarhumeral articulation, had the highest frequency among the females.

Ortner (1968) uses Angel's (1966) term "atlatl elbow" to cover the three conditions of deterioration found on the capitulum; porosity, eburnation, and destruction and remodeling of the surface. An Eskimo sample he investigated had a frequency of 18% capitular degeneration in the left elbow; a Peruvian sample exhibited a 4.8% frequency with capitular deterioration in the left humerus. Ortner recognizes that genetic factors may contribute to the relative differences in the two samples.

The results of Pfeiffer's (1977) study of the Canadian Great Lakes Indians showed a higher frequency of involvement of the capitular surface than the other humeral articular areas. The male sample exhibited more involvement on the right, the female sample more on the left.

Changes in the medial epicondylar epiphysis, the articulating surface of the capitulum and the opposing radial head were found in an investigation of Little League and Pony League pitchers between the ages of 9 and 14 years (Adams 1965). The author states that excessive repetitious trauma is the major contributing cause.

The lateral trochlea ridge displayed the greatest amount of involvement of the humeral variables in both the Averbuch and Indian Knoll samples; this component of the ulnarhumeral articulation often is involved with degenerative lesions associated with different activities involving throwing an object. Osteophytes were found on the lateral margin of the humeral trochlea in 36% of the playing elbow and 13% of the non-playing one in a study of world caliber tennis players. Hypertrophy of the osseous elements as well as the muscular ones occurred on the playing side (Priest et al. 1977). Hypertrophy of the humerus is consistent also in professional baseball pitchers (King et al. 1969).

"Tennis elbow" is a relatively common occurrence among those who play tennis or engage in other activities requiring the extension of the elbow and an impact during pronation or supination. Lateral epicondylitis is the most common result, although medial epicondylitis and cubital tunnel pain may also result (Priest et al. 1977); in severe cases osseous damage occurs. Enlargement of the coronoid tubercle as well as the spurring of the lateral margin of the trochlea may ensue.

Three cases of "tennis elbow" in non-tennis playing aviators were described by Farr (1982), all apparently from over-extension of the elbow with a sudden stress applied. Lateral epicondylitis was diagnosed in the three cases; no radiographs were utilized in the diagnosis.

It is apparent from these reports that several activities may contribute to "tennis elbow". Other reports suggest that dog-walker's elbow (Mebane 1981) and hooker's elbow, a result of hooking a fish through the ice, (Dahl 1981) should be subsumed under "tennis elbow". On the other hand, Garden (1961) states that "tennis elbow" is an affliction of middle age.

Miller (1985) found a pattern of involvement of elbow lesions similar to "tennis elbow" in a prehistoric skeletal series from Arizona. The pattern of involvement on the capitulum and trochlea of the humerus, the high frequency of pathological changes on the ulna, and the bilaterality of the lesions suggested to him that the use of the two-handed mano used in food preparation was a major contributing factor in the degenerative changes found within the elbow joint.

A different pattern of deterioration within the elbow was found in a study of baseball pitchers. Wilson et al. (1983) determined that a valgus extension overload created an osteophyte on the posteromedial aspect of the olecranon process in all pitchers studied. An area of chondromalacia may result on the opposing medial aspect of the olecranon fossa.

Haney (1974) found two males in her sample of seventeen adults in a Central California prehistoric skeletal series with osteophytic growth within the olecranon fossa and suggests that they are examples of atlatl elbow.

Lesions on the coronoid process are typical of the deterioration pattern within the elbow of wrestlers (Layani et al. 1960); the elbow is the most heavily affected joint in this occupational group.

The pattern of involvement of the elbow components suggests that both the Averbuch and Indian Knoll population samples were engaged in activities which entailed extension of the arm and heavy utilization of the joint as a whole. The use of the atlatl and spear and the grinding of seeds and nuts by the Indian Knoll group and the use of the bow and arrow, hoe and other agricultural implements, and grinding of nuts, seeds, and corn by the Averbuch group could account for the pattern of involvement of degenerative lesions in the elbow.

Bone and Joint Totals

The variables of each element of the elbow were combined to produce a bone total for that element, the distal humerus, ulna, and radius; these were added together to create an elbow total. Table 8.6 shows the probabilities of the means of the bone and joint totals being the same by agegroups. Only in the agegroup overforties are the differences in the means not highly

TABLE 8.6

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME.
BONE AND JOINT TOTALS BY AGEGROUPS
WITH SEXES AND SIDES COMBINED

Variable	Twenties					Thirties					Overforties					Ages Combined				
	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK		Av	IK	Av	IK	
Humer	106	126	3.91	2.66	.0000	48	188	5.17	3.35	.0000	20	64	6.35	4.17	.0000	179	378	4.58	3.26	.0000
Radius	93	116	1.84	1.28	.0000	47	163	2.30	1.71	.0000	20	54	2.20	1.91	.5176	164	333	2.04	1.59	.0000
Ulna	99	115	4.77	2.97	.0000	47	178	6.02	3.98	.0000	20	58	6.80	4.81	.0000	173	351	5.43	3.79	.0000
Elbow	46	105	12.50	6.90	.0000	22	150	14.59	8.84	.0000	7	45	12.71	10.89	.1781	77	300	11.99	8.47	.0000

statistically significant (p=.0000) for the radius and the total elbow.

The humerus, radius, ulna, and elbow totals were divided into three degree of severity; none/slight, moderate, and severe. These categories were designed to correspond as closely as possible to the degrees of osteoarthritis depicted in the <u>Atlas of Standard Radiographs of Arthritis</u> (1963). The degree of severity was coded as follows:

Elbow Degree of Involvement

	None/slight 1	Moderate 2	Severe 3
Distal Humerus	0-2	3-7	8-11
Radius	0-1	2-4	5-6
Ulna	0-3	4-6	7-10
Elbow	0-6	7-15	16-21

In the following tables, the degree of severity is represented numerically; i.e. none/slight is 1, moderate is 2, severe is 3. The frequencies, Chi-square approximations and probabilities were computed using the FREQUENCY software package of SAS Institute Inc. (1985).

The distal humerus exhibits a higher frequency of involvement than the other elements in the agegroup twenties, Table 8.7, the radius the second highest involvement and the ulna the least involved. The Averbuch

TABLE 8.7

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP TWENTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	106	16.04	83.96	00.00	126	37.30	62.70	00.00	13.030	.000	1
Radius	93	25.81	74.19	00.00	116	69.83	30.17	00.00	40.012	.000	1
Ulna	99	32.32	51.52	16.16	115	85.22	14.78	00.00	65.679	.000	2
Elbow	46	17.39	80.43	02.17	105	37.14	62.86	00.00	7.741	.021	2

sample consistently displays a greater frequency of involvement for all variables than does the Indian Knoll sample. The Indian Knoll sample contains no examples of severe involvement of any element while the Averbuch sample has a 16.16% frequency of severe degenerative disease on the ulna and a frequency of 2.17% for the total elbow.

In the agegroup thirties, Table 8.8, the ulna becomes the most involved element as well as the most severely involved variable in the Averbuch sample with a 38.30% severe involvement; the distal humerus still has the highest frequency in the Indian Knoll sample. There is involvement to the severe degree in both samples and all variables except for the Indian Knoll radius.

By the agegroup overforties, Table 8.9, all the individuals in the Averbuch samples are involved at the moderate or severe degree on the distal humerus. The ulna remains the most severely affected element in the Averbuch group. The pattern is the same for Indian Knoll with the humerus more frequently involved at any level and the ulna the most severely affected. While being the most severely affected element the ulna is also the least frequently affected element in the Indian Knoll sample. The radius is the least affected of the three elements for the Averbuch sample.

TABLE 8.8

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP THIRTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	48	14.58	79.17	06.25	188	26.60	72.34	01.06	7.380	.025	2
Radius	47	10.64	87.23	02.13	163	34.97	65.03	00.00	13.352	.000	2
Ulna	47	08.51	53.19	38.30	178	58.99	35.39	05.62	54.478	.000	2
Elbow	22	09.09	45.45	45.45	150	14.00	83.33	02.67	47.008	.000	2

TABLE 8.9

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS IN AGEGROUP
OVERFORTIES

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	20	00.00	80.00	20.00	64	04.69	93.75	01.56	9.958	.007	2
Radius	20	25.00	70.00	05.00	54	18.52	81.48	00.00	3.248	.197	2
Ulna	20	10.00	25.00	65.00	58	37.93	50.00	12.07	22.153	.000	2
Elbow	7	00.00	71.43	28.57	45	00.00	93.33	06.67	3.344	.067	1

The Eskimo sample which Jurmain (1975) examined exhibited an earlier age at onset, a higher prevalence, and a more severely involved elbow than the Pecos sample or the two modern samples from the Terry collection. The individuals from Pecos apparently developed deterioration of the elbow at a later age beginning in the fifth and sixth decade.

Merbs (1983) found a 16% prevalence of elbow lesions in the Sadlermiut Eskimo sample; the male sample expressed more involvement than that of the female, and in both sexes the right side was more involved.

The combined samples of Averbuch and Indian Knoll including all agegroups, Table 8.10, repeats the pattern exhibited in the overforties agegroup with the distal humerus the most frequently involved element and the ulna the most severely affected bone in the elbow in both population samples. Averbuch is the more involved sample for all variables and the most severely involved.

Jurmain (1975) found the distal humerus consistently the most involved element in the elbow in his investigation of four samples, the radius was more severely involved more often, and the ulna more often moderately involved. The Eskimo sample was the most involved of the four samples he examined for all three elements.

TABLE 8.10

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT.
BONE AND JOINT TOTALS WITH AGEGROUPS,
SEXES, AND SIDES COMBINED

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	174	13.79	82.18	04.02	378	26.46	72.75	00.79	16.763	.000	2
Radius	160	21.25	77.50	01.25	333	44.44	55.56	00.00	28.215	.000	2
Ulna	166	22.89	48.80	28.31	351	64.10	31.05	04.84	97.427	.000	2
Elbow	75	13.33	69.33	17.33	300	20.00	77.67	02.33	27.289	.000	2

An investigation of ship caulkers and a sample of controls was undertaken in Italy to determine the effects of pneumatic portable tools on the arms and hands. Ten percent of the shipyard workers who had been exposed to hand-arm vibration had roentgenological findings in the elbow; 10% appeared with exostoses in the olecranon and 5.3% on the radial tuberosity (Bovenzi et al. 1980). No results were discussed concerning the controls. In an earlier study of the effects of using pneumatic tools, 8.9% of riveters, 22% of caulkers, and 50% of scalers exhibited signs of arthritic changes. The most severe changes were in the scalers; the vibration frequency of their tool is approximately 6000 strokes per minute (Hunter et al. 1945).

A survey of osteoarthritis in Bulgaria was undertaken to discover the prevalence within the urban population of Sofia. A definite progression with age was noted with a prevalence rate of 3.6% elbow lesions with the ages and sexes combined (Tzonchev et al. 1968); the females expressed a higher prevalence than the males, 4.6% females 1.8% males.

The elbow was the second most affected joint in a study of coal miners in England (Lawrence 1955). The control group of light manual and office workers yielded no cases of osteoarthritis of the elbow.

The Tranquillity site in California yielded a frequency of 46% (6 of 13 individuals) elbow arthritis. Eburnation over the capitulum was the most usual pattern (Angel 1966). This pattern of pathological changes Angel termed "atlatl elbow" although two of the four females in his sample were similarly affected although not to the same degree. He suggests that seed grinding may have some effect.

Kelley (1979) found a 7.5% frequency of elbow arthritis in the Libben Site sample. Rathbun (1984) uses the data from his 1980 research to determine a 21% frequency of elbow lesions in a metal age sample from Iran and Iraq.

Comparative data frequencies by sex for the current study are listed in Table 8.11. The pattern of involvement for the female sample of both groups and the Indian Knoll males is identical with that of the combined sample. The males of Averbuch, however, exhibit the same frequency of involvement on the humerus and ulna, 85.71%, although the severity of the ulnar changes is still greater. The females of Averbuch have the highest frequency of involvement on any element, the humerus. The Indian Knoll males and females exhibit a pattern of involvement very similar to each other, the ulna displays a difference between the sexes. The humerus is the most

TABLE 8.11

ELBOW: COMPARISON OF FREQUENCIES OF BONE TOTALS
BY SEX. AGEGROUPS AND SIDES COMBINED

Female

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	87	12.64	83.91	03.45	172	26.74	72.67	00.58	9.248	.010	2
Radius	77	20.78	77.92	01.30	155	39.35	60.65	00.00	9.675	.008	2
Ulna	89	30.00	44.44	25.56	162	73.46	21.60	04.94	47.638	.000	2
Elbow	35	08.57	74.29	17.14	140	18.57	80.00	01.43	16.931	.000	2

Male

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	87	14.29	80.46	04.60	206	26.21	72.82	00.97	7.803	.020	2
Radius	83	21.69	77.11	01.20	178	48.88	51.12	00.00	18.982	.000	2
Ulna	77	14.29	53.25	32.47	189	56.08	39.15	04.76	57.101	.000	2
Elbow	40	17.50	65.00	17.50	160	21.25	75.63	03.13	11.732	.003	2

involved, the radius second, and the ulna affected the least frequently but the most severely.

Examining the complete elbow joint, it is apparent that the female sample is more frequently involved than that of the male in both Averbuch and Indian Knoll. The males display a greater degree of severity of degenerative changes than the females.

Pickering (1979) found that women underwent more stress and that the age of onset was earlier in them than in males in an archaeological sample from the prehistoric Late Woodland site, the Ledders site in Illinois. The ulna was the most heavily involved element of the elbow in the females.

The rank of individuals within a prehistoric Amerindian sample apparently contributed to the activity level of the individuals and thus to the degree of severity of degenerative joint disease within the elbow (Tainter 1980). The females of the high rank had a frequency of involvement of 00% while the females of the lower ranks had a frequency of 25% for the rotational component of the elbow. Similarly the high ranking males exhibited a 12.6% frequency and the lower ones a 42.9% frequency of involvement for the same component. For the flexion/extension component, the females of the first rank expressed a frequency of 3.75% and the lower ranked ones

3.69%, the males of high rank showed a frequency of 1.34% and their underlings a 5.09% frequency of involvement.

In the current study the data from the Averbuch and Indian Knoll skeletal series were also analyzed by side in an attempt to determine a pattern which might suggest cultural activities and to provide comparative data for other researchers; the frequencies of involvement are presented in Table 8.12.

Surprisingly, the left elbow was more frequently involved in degenerative changes at Averbuch than was the right; there was also more severe involvement in the left elbow. Indian Knoll exhibited more frequent involvement in the right elbow than in the left as well as more severe involvement.

Kilgore (1984) found that the left elbow was more frequently involved than the right in an archaeological sample from medieval Nubia. Merbs and Vestergaard (1985) reported similar results from a prehistoric sample from Arizona. Two of ten adults they examined have severe arthritic changes in the elbow and considerably more involvement in the left side. However, the patterns they display for the shoulder region are different.

In contrast, the right elbow was more involved than the left in the sample of Sadlermiut Eskimos which

TABLE 8.12

ELBOW: FREQUENCY OF INVOLVEMENT BY SIDE

Left Elbow

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob.	DF
Humerus	86	17.44	79.07	03.49	187	31.55	68.45	00.00	11.775	.003	2
Radius	76	19.74	78.95	01.32	165	43.64	56.36	00.00	14.584	.001	2
Ulna	77	20.78	51.95	27.27	177	67.23	31.51	02.26	62.556	.000	2
Elbow	36	08.33	72.22	19.44	150	24.00	75.33	00.67	7.102	.029	2

Right Elbow

	Averbuch				Indian Knoll						
Variable	N	1	2	3	N	1	2	3	X2	Prob	DF
Humerus	88	10.23	85.23	04.55	191	21.47	76.96	01.57	6.888	.000	2
Radius	84	22.62	76.19	01.19	168	45.24	54.76	00.00	13.754	.001	2
Ulna	89	24.72	46.07	29.21	174	60.92	31.61	07.47	37.998	.000	2
Elbow	39	17.95	66.67	15.38	150	16.00	80.00	04.00	7.102	.029	2

Merbs (1983) investigated; this was true for both the sexes.

For the Averbuch and Indian Knoll samples the probabilities that the means are the same by sex and side are presented in Tables 8.13 and 8.14. No explanatory material is necessary.

Jurmain's (1975) results indicate that modern American males show more degenerative elbow involvement than females; his analysis of the Terry collection resulted in the Chi-square significances for the right elbow of .063 for Whites and .023 for Blacks. Larsen's (1980, 1984) comparison of a pre-agricultural sample and an agricultural one in Georgia coast prehistoric archaeological series indicated a decrease in involvement as agriculture became more important; the percentages went from 9.1% to 2.3% with ages, sexes, and sides combined. The frequency of involvement for the female sample declined from 9.6 % to 0.0%, the male sample from 13.7% to 6.1%.

An examination of the symmetry of the degenerative changes in the elbow found that 89.2% of the females and 85% of the males of Indian Knoll, and 87.5% of both the males and the females at Averbuch exhibited a symmetrical degree of involvement bilaterally. In the Indian Knoll sample 70% of the asymmetric males had

TABLE 8.13

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME BY SEX

Variable	Female					Male				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Humerus	88	172	4.49	3.21	.0000	91	206	4.67	3.30	.0000
Radius	77	155	2.04	1.65	.0004	87	178	2.05	1.54	.0000
Ulna	90	162	5.07	3.49	.0000	83	189	5.83	4.05	.0000
Elbow	35	140	12.23	8.31	.0000	42	160	11.79	8.61	.0000

TABLE 8.14

ELBOW: PROBABILITIES OF THE MEANS BEING THE SAME BY SIDE

Variable	Left					Right				
	N		Mean		Prob	N		Mean		Prob
	Av	IK	Av	IK		Av	IK	Av	IK	
Humerus	88	187	4.44	3.10	.0000	91	191	4.71	3.42	.0000
Radius	77	165	2.06	1.58	.0000	87	168	2.02	1.60	.0000
Ulna	79	177	5.43	3.67	.0000	94	174	5.44	3.91	.0000
Elbow	36	150	12.06	8.12	.0000	41	150	11.93	8.82	.0000

none/slight on the left and moderate on the right, 20% expressed a degree of moderate changes on the left and severe on the right, and 10% displayed severe changes on the left and moderate on the right. Of the females in Indian Knoll with asymmetry, 80% show none/slight on the left and moderate changes on the right, 10% present moderate changes on the left and severe ones on the right, and 10% display the opposite pattern.

In the Averbuch sample only one female exhibits a pattern of changes with the left side severe and the right side moderate; one male has the opposite pattern of left moderate with right severe. The sample of individuals with both elbows present at Averbuch was small, the total was 8 males and 8 females.

In Jurmain's (1975) combined sample 83.6% of the sample were symmetrical; 16.4% displayed an asymmetric pattern for the degree of involvement. Of the symmetric sample 74.8% showed none/slight, 6.7% moderate and 2.1% severe. Of the asymmetric group 11.8% had none/slight with moderate, 3.4% moderate with severe and 1.1% none/slight with severe.

In the Terry collection the elbow was the most asymmetric joint (Jurmain 1980); those areas under more functional stress (the mixed rotary components of the humerus and radius) were the most asymmetrically involved.

Occasionally degenerative changes in the elbow will be discovered that are so extensive that they would have prevented normal activities. An archaeological sample from New Mexico yielded an individual with a heavy vertebral involvement of Schmorl's nodes on seven vertebrae and extensive eburnation and osteophytic growth on the right elbow (Wheeler 1985). The degenerative changes were so severe that complete flexion would have been impossible.

In Table 8.15 the Averbuch and Indian Knoll series are compared by sides within the individual samples to determine if there is a statistical difference in the means.

The mean of the right side is higher for the Averbuch humerus and ulna, but the left side shows a higher mean for the radius and total elbow joint. None are statistically significant at any level. The Indian Knoll sample exhibits a different pattern with the right side always having a higher mean. If the level of significance is lowered to $p=.05$ then the distal humerus shows a statistical difference in the sides.

In Table 8.16 the differences between the sexes is tabulated. The males at Averbuch have a higher mean on the variables except for the total elbow joint. The males at Indian Knoll also have a higher mean on all variables

TABLE 8.15

ELBOW: PROBABILITIES OF THE MEANS OF THE SIDES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch N Left	Averbuch N Right	Averbuch Mean Left	Averbuch Mean Right	Averbuch Prob	Indian Knoll N Left	Indian Knoll N Right	Indian Knoll Mean Left	Indian Knoll Mean Right	Indian Knoll Prob
Humerus	88	91	4.44	4.71	.2476	187	191	3.10	3.42	.0375
Radius	77	87	2.06	2.02	.7431	165	168	1.58	1.60	.9959
Ulna	79	94	5.43	5.44	.9371	177	174	3.67	3.91	.2405
Elbow	36	41	12.06	11.93	.9346	150	150	8.12	8.82	.1015

TABLE 8.16

ELBOW: PROBABILITIES OF THE MEANS OF THE SEXES BEING THE SAME. WITHIN THE SAMPLE

Variable	Averbuch N Male	Averbuch N Female	Averbuch Mean Male	Averbuch Mean Female	Averbuch Prob	Indian Knoll N Male	Indian Knoll N Female	Indian Knoll Mean Male	Indian Knoll Mean Female	Indian Knoll Prob
Humerus	91	88	4.67	4.49	.3467	206	172	3.30	3.21	.8824
Radius	87	77	2.05	2.04	.8933	178	155	1.54	1.65	.0886
Ulna	83	90	5.83	5.07	.0091	189	162	4.05	3.49	.0011
Elbow	42	35	11.79	12.23	.9795	160	140	8.61	8.31	.8382

except the radius. The difference in the variable ulna is statistically significant between the sexes at Indian Knoll ($p=.0011$) and at Averbuch ($p=.0091$).

CHAPTER IX

DISCUSSION

Current Prevalence of Degenerative Joint Disease

The impact of arthritis is keenly felt in modern society. The rheumatic diseases, although not life-threatening, take their toll on the human species in other manifestations. Over 27 million days were lost from work in the United States in 1962 due to the arthritides; this number does not include over 569,000 men and women who were unable to work at a job either in business or at home during that year (Woolsey 1963). Slightly over twenty percent of the absenteeism of face workers in the coal mining population of Scotland surveyed by Anderson *et al.* was contributable to the rheumatic diseases (1962). Anderson (1974:521) states that "...thirty million man days are lost to industry every year in Britain on account of rheumatic diseases." The absentee rates of dockyard workers in the Edinburgh area of Scotland averaged 33.9 weeks per 100 workers interviewed (Anderson and Duthie 1963). Several kinds of rheumatic complaints were included in this figure. Interestingly enough it was discovered that the "...complaint ratio (was) not dependent of heaviness of job...." (Anderson and Duthie 1963:403).

Thirty-seven percent of the rheumatic disorders surveyed by Bunim in the Consolidated Edison Company in the early 1950s were determined to be osteoarthritic in nature (1953). Approximately 4% of the United States population between the ages of 65-74 years have some restriction to their physical activities in everyday life due to some form of arthritis. This figure excludes institutionalized and non-civilian individuals (Maurer 1979). The prevalence rate would increase dramatically if it included the inhabitants of hospitals and nursing homes. Fifteen percent of the outpatients seen in a health district in West Sussex, England were diagnosed as osteoarthritic (Holden 1982); the mean age of these patients was 75.5 years.

Contributing Factors

Osteoarthritis is definitely correlated with age (Jurmain 1975), but other factors contribute to a high degree. Osteoarthritis patients had been more active in sports at an earlier age than a control group (p=.05) in a survey conducted in a group of Finnish health centers; the average age of both the controls and the osteoarthritis patients was 58 years (Julkenen et al. 1981). Stulberg (1980) suggests that "...if participation in a sport leads one to perform awkward joint motions, and if these motions are repeated vigorously and for prolonged periods of time, the joint...may ultimately be damaged." Williams (1979) questions whether it is the stress which causes the degeneration of the joint or failure to deal with the effects of stress. It appears that "...adaptation to withstand the stresses and strains of strenuous physical exercise also take place, particularly if this commences in adolescence." (Adams 1979).

Many researchers feel that the manifestation of osteophytes is a compensatory mechanism to add to the articular area of the surface of the joint in order to effect a larger working area. Although remodeling of cortical bone constantly takes place, the development of osteophytes at an early age is a definite indication that the joint surfaces are under abnormal stress.

Subsistence and Health in Samples

In addition to mechanical stress, poor nutrition, genetic predisposition, and viral infection may all contribute to the breakdown of skeletal tissue (Goodman et al. 1984). When these factors affect the population as a whole inferences concerning their causes may be made. Stress develops within a population to a greater degree in the transitional period encompassing the primary introduction of a new subsistence base and decreases as adaptation to the new pattern of ecological dependency successfully is accomplished (Rose et al. 1984).

Analysis of the skeletal data from the two prehistoric sites, Indian Knoll and Averbuch, indicates that the Averbuch population was disadvantaged nutritionally. Dental analysis suggests that this is true of both populations although the deficiencies were different (Perzigian 1977, Berryman 1981, Jablonski 1984, Eisenberg 1986).

Averbuch

The Averbuch site is considered to be a "marginal" site in the late Mississippian tradition, located away from a main waterway and with a smaller population than the prototype Mississippian habitation area (Eisenberg 1986). The location of sites in marginal areas may reflect population pressures within the more desirable habitation regions (Klippel 1984, Klippel and Reed 1984). The importance of agriculture to the population subgroup residing at this particular site has been under recent investigation. Eisenberg (1986:173) suggests that the pattern of pathological lesions on the skeletal remains indicates an "...overreliance of maize agriculture."

Reconstructing the botanical population of the Averbuch site is difficult since the majority of the species are not preserved due to the soil, moisture and temperature conditions in the Nashville Basin (Crites 1984). Only those varieties carbonized in recognizable form can be tabulated and analyzed. Crites found that maize occurred as often as any other plant species; only a narrow suite of floral varieties were recovered. The botanical data recovered suggests the possibility of nutritional stress although it may have been tempered by faunal aspects of diet.

The consequences of maize consumption differed among the Mississippi Valley prehistoric populations which Rose et al.(1984) compared for nutritional and pathological indicators. Their work suggests that population nucleation and change in culture, not just the adaptation to maize agriculture, are major factors in increasing stress and health problems. Their findings confirm those in other recent studies which concentrated on the Averbuch site (Berryman 1981, Jablonski 1984, Eisenberg 1986). Berryman examined stress indicators such as Harris lines, the mortality rate, enamel hypoplasia, and the pattern of decreased stature. He found that 93% of the males and 83% of the females displayed enamel hypoplasia in the mandibular canines and 93% of the males and 81% of the females had developed Harris lines. Apparently the males either were more stressed or less capable of coping with environmental stress than the females. Perhaps chronic stress resulted from population pressure and the subsequent splintering of villages into smaller settlements on less desirable farm land (Berryman 1981).

Rose et al. (1984) examined Caddoan skeletal series from the Red River Valley and the Arkansas and Ouchita Rivers and found that in those series the osteoarthritis rates declined when agriculture was first introduced and used as a supplement to hunting and gathering; the rates then rose as the Caddoan were more dependent on agricultural subsistence.

One generalized statement made by Yesner (1980) is that, with the exception of those dependent upon shellfish or low-fat fish, during the transitional period from hunting and gathering to agriculture "...there was a substantial reduction in dietary proteins and fats, but an increased consumption of carbohydrates...."

The life expectancy at birth of the Averbuch population was reconstructed by Berryman (1981); his results indicated that females could expect to live 14.6 years and the males 17.4 years. The crude mortality rate was estimated as 60 deaths per 1000 individuals per year. Most deaths, other than those of infants, occurred during the young adult age of 15 to 30 years.

Indicators of social stress present at the

Averbuch site include palisade walls surrounding the village, evidence of scalping on both male and female skulls, and projectile points embedded in the recovered remains.

Among the lithic assemblage recovered at the Averbuch site were thirty classic Mississippian stone arrow points; over a hundred non-Mississippian projectile points/knives were recovered. Nine hoe blades/digging tools were uncovered, one blade was complete.

The intensity of involvement of degenerative joint disease in the Averbuch sample is undoubtedly influenced by genetic, environmental, and nutritional factors.

Indian Knoll

One of the characterizations of the Archaic Stage is the utilization of plant foods (Fowler 1971); the culmination of the Archaic Stage being expressed by semi-sedentary groups exploiting a variety of resources in particular areas. The utilization of a varied diet in which no one food is dominant is likely to be highly nutritious because the varied nutrient components complement each other (Scrimshaw 1983).

The utilization of river mussels and snails is certainly in evidence with the enormous shell mound habitation site. There is some question concerning the importance of these bivalves in the diet of early American

Indians (Parmalee and Klippel 1974). Although the appearance of shell mounds tempts one to assume that freshwater mussels were a primary subsistence item, consideration of the size and caloric value of each animal demotes them to the level of a supplemental food item. Deer, turkey, dog, and other small mammals were exploited for food; the remains of deer are relatively scarce at Indian Knoll suggesting that either the artiodactyles were not a main subsistence item or that they were utilized in a different vicinity. Of the flora presumed to be utilized in the diet at Indian Knoll, only three species are listed in Webb's report (1946); acorns, black walnuts, and hickory nuts. This lack of recovered floral remains is probably due to the state of archaeological techniques around 1940 (Cassidy 1980).

Cassidy (1980) discussed the reconstruction of diet at the Archaic Indian Knoll site and the influence of it upon the individuals residing there. Her comparison of the Indian Knoll skeletal material with that of the agriculturalists at Hardin Village indicated that the individuals at Indian Knoll had access to a better diet. The lack of definitive porotic hyperostosis or cribra orbitalia lesions at Indian Knoll indicated an absence of iron-deficiency anemia. The Indian Knoll people, in general, were healthier than the agricultural Hardin Village.

A different view was expounded by Perzigian (1977) who, in analyzing the pattern of dental asymmetry in the Indian Knoll skeletal series, states that the group as a whole was disadvantaged socioeconomically and nutritionally; the skeletal data indicated "...severe growth limiting factors." (1977:107).

Cassidy determined that the life expectancy at birth for the Indian Knoll sample was 21.84 years for the males and 17.92 years for the females (1972), considerably higher than the life expectancy for Averbuch.

Lee (1968) discussed modern day hunters and gatherers and extrapolated from a study of !Kung San that the existence of hunting and gathering groups was not precarious but reliable and occasionally abundant. Ethnographic research shows that plant food contributes to the bulk of their diet although only few remains of these flora are found in present day !Kung sites due to poor preservation. It is, however, difficult to generalize about models utilizing extant hunting and gathering groups since different groups through time must have utilized widely different subsistence patterns depending on the region and resources available (Yesner 1980) and differing cultural practices.

Artifacts recovered from graves at the Indian Knoll site include hooks and weights for atlatls and projectile points for spears; the atlatl components were present both in male and female graves and in a few infant graves. These artifacts represent the primary weapons for hunting the larger game animals.

The Knee

Osteoarthritis of the knee was prevalent in both the Averbuch and Indian Knoll samples, the combined Averbuch group displayed a higher degree of involvement than the combined Indian Knoll group ($p=.0000$). The Averbuch sample exhibited a 5.45% frequency of severe involvement while the Indian Knoll sample exhibited 2.14% frequency. A different pattern between the sexes was noted with the Indian Knoll females having no severe involvement of the knee and the Averbuch females exhibiting a 4% frequency. As was discussed in Chapter V there is a great inconsistency in frequency rates between the sexes in different published reports; some differences are real and some the artifacts of different diagnostic methods and interobserver methodologies.

Age is not an important factor in the frequency rates of the two archaeological samples under present consideration; they both consist of individuals under the age of 60 years, and the more severely affected sample, Averbuch, is slightly younger although not statistically significantly so.

The left knee is consistently the more involved than the right in both population samples; these results are consistent with those of Kilgore's (1984) investigation of a Nubian population sample (A.D. 550-1450).

Activities which might influence a greater development of osteoarthritis of the knee among the Averbuch sample are occupations relating to agriculture; lifting and moving stones to clear land and working on rough terrain. Professional weightlifters exhibit more degenerative joint disease in the knee than in other joints (Fitzgerald and McLatchie 1980). It has been previously suggested that traversing on rough footpaths and terrain may aggravate the knee joint (Bremner et al. 1968). There is also evidence of warfare within the Averbuch community, scalping marks upon the skull and projectile points embedded in bones. Knee injuries and microtrauma beginning in late adolescence might result from fighting on uneven ground.

The Hip

Severe osteoarthritis of the hip is normally limited to the elderly in the modern developed countries, however early onset of coxarthrosis does occur under certain circumstances. In the present study the combined Averbuch sample shows a higher frequency of severe involvement, 16.88%, than does the Indian Knoll sample, .37% . The Averbuch population shows an early onset of this disease with a 6.52% frequency of involvement in the agegroup twenties. Indian Knoll, on the other hand, shows no severe involvement until the overforties agegroup. There is evidence that various athletic activities undertaken in adolescence may be an important factor in the early onset of osteoarthritis of the hip (Murray and Duncan 1971).

The Averbuch females show a high frequency level of 12.5% severely involved and the males 21.62% severely affected. The Indian Knoll females exhibit no severe involvement and the males only .69% frequency of severe involvement.

Edynak (1976) examined four Yugoslavian archaeological samples dating from the fourteenth through sixteenth centuries. In the males the hip was more severely affected with osteoarthritis than the other joints and the degenerative lesions also appeared earlier than in other joints. Subsistence was based upon raising cattle, horses, and sheep; some agriculture; and cattle transport; it is presumed that the males were either pastoralists or soldiers. Edynak suggests that pelvic shock from riding horses may have been one aetiological factor in the high degree of severe involvement for this particular skeletal series.

It is apparent that some form of chronic trauma in the adolescent and early adult years is an important factor in the development of severe osteoarthritis of the hip in the Averbuch group. This does not rule out a genetic predisposition to an increase in anteversion angle or other structural abnormality although they normally manifest themselves in later years.

The Shoulder

A high degree of degenerative joint disease was found in both archaeological samples examined in this study. The combined Averbuch sample exhibits a higher total frequency of involvement and the combined Indian Knoll sample displays a higher frequency of severe involvement, 4.30% to Averbuch's 4.13%. When the sexes are divided a different pattern occurs, the females of Averbuch display a 7.02% frequency of severe involvement while those of Indian Knoll exhibit a .91% frequency. The males exhibit an opposing pattern with the Averbuch males displaying only a 1.56% frequency of severe involvement and the males of Indian Knoll a 6.85% frequency of severe changes. It is apparent that either the women in the agricultural Averbuch population are utilizing the shoulder joint in a more stressful manner than the males or that their skeletal frames are unable to cope with stress as well as are those of the males.

A similar pattern was discovered when Edynak (1976) examined skeletal material from Yugoslavia in an attempt to correlate the pattern of pathological lesions with life-style. Material from four small burial mounds dating from the 14th-16th centuries was utilized. The mature females exhibited heavy shoulder degenerative changes which were consistent with chronic physical stress. Activities such as heavy lifting and carrying, building homes and fences, and working in the fields were suggested as contributory factors.

Women in general work more hours than men whether a simple or intensive form of agriculture is practiced (Ember 1983). More hours are expended in the fields with simple agriculture and more hours processing food when intensive agriculture becomes dominant. Stored products are usually in a dried state and require the grinding and pounding of grain and seeds; more fuel and water must be drawn and carried for soaking and cooking, traditionally woman's work.

Bilateral shoulder involvement was exhibited in the Sadlermiut Eskimo sample which Merbs (1983) examined, the males in this group consistently displayed a higher frequency of involvement than did the females.

The pattern of severe involvement among the males at Indian Knoll suggests a heavier reliance on throwing motions such as would be consistent with use of the atlatl and spear.

The Elbow

The pattern of involvement of degenerative joint disease within the elbow joint indicates that both the Averbuch and Indian Knoll populations were employed in activities which involved intense use of the elbow. The Averbuch sample developed osteoarthritis at an earlier age but both groups were universally affected by the agegroup overforty. The males of both population samples expressed more severe involvement than the females. The pattern exhibited in both groups is consistent with a repertoire of activities which entail the often violent extension of the elbow. Use of the atlatl and spear in the Indian Knoll group and use of the bow and arrow, hoe and other agricultural implements are consistent with the pattern expressed in the elbow. As was mentioned earlier, evidence of these tools was recovered from both sites.

The more frequent involvement of the females is related to the more continuous occupations of the grinding of seeds, corn, and nuts. It is probable that the females at Averbuch were also employed in agricultural endeavors requiring heavy lifting and carrying.

CHAPTER X

SUMMARY AND CONCLUSIONS

The purposes of this study were to compare the prevalence of degenerative joint disease between two prehistoric American Indian skeletal series, one of which was pre-agricultural and the other agricultural, and to determine the differences in the pattern of involvement. The goals of the investigation were to explore the possibilities of inferring activity patterns within the joints and relating them to cultural activities. This comparative biocultural approach must of necessity consider nutritional, demographic, and environmental constraints upon the populations under consideration.

The populations studied were selected for several reasons. Both are relatively large with reasonably complete skeletal remains. The differences in their subsistence strategies made the two samples ideal for comparison; the residents of Indian Knoll relied on hunting and gathering for subsistence and were probably semi-nomadic, while the residents of Averbuch were agriculturalists and lived a sedentary but stressful life. The archaeological sites are located in similar environmental settings separated temporally by approximately 4000 years and spatially by approximately 200 linear miles; the degree of genetic homogeneity between the two population samples is unknown. A survey of literature as well as current laboratory research agree that the Averbuch population was a disadvantaged culture group, there are conflicting ideas concerning the nutritional adequacy of the Indian Knoll population (Cassidy 1972, Perzigian 1977).

The Averbuch series was excavated under optimal conditions with complete recovery techniques utilized. The thoroughness of recovery resulting from the archaeological techniques employed makes the Averbuch skeletal series extremely useful for populational analyses and the artifact assemblage equally important for cultural reconstruction.

Little was known of the marginal populations of the Mississippian Phase until this Averbuch site was excavated and analysis begun; a new understanding of the people inhabiting these outlying areas is emerging as current scientific research continues to examine the artifacts as well as the skeletal remains.

The Indian Knoll site was excavated before some of the more advanced techniques were utilized; for example, during the first excavation activity often only skulls were saved and the postcranial remains co-mingled.

The hypotheses addressed in this thesis were:

a. There will be a difference in the pattern of involvement of degenerative joint disease between agricultural and gatherer-hunter populations in prehistoric cultures.

b. If there is added nutritional and activity stress due to the change to incipient agriculture, the degree of involvement will be greater.

The first hypothesis was supported by the results in that there are definite differences in the pattern of osteoarthritis between the two sample skeletal series, the most immediately apparent being the higher degree and frequency of involvement in the agricultural sample.

The second hypothesis was also supported in that the degree of involvement of osteoarthritis is statistically greater in the Averbuch group. It would be very difficult to attribute the consistently higher involvement within the Averbuch sample to an increased intensity in mechanical activity alone although the preliminary results of current research suggest that the hands of the Averbuch population were also subjected to intense and heavy mechanical manipulation (Goldsmith, 1987, personal communication). Other factors such as nutritional deprivation, pathological, or cultural stress are in all probability also involved to compound the severity of these pathological changes.

The variation in frequency levels of degenerative joint disease between skeletal series examined by different researchers may actually reflect different activity levels and patterns, but they may also reflect genetic differences as well as varying methods of scoring the pathological lesions, differences in diagnostic methods, and sampling techniques. Consequently drawing inferences from comparisons of frequencies computed by different researchers may be fraught with pitfalls.

The results of this investigation demonstrate a surprising consistency of a higher level of degenerative joint disease in the Averbuch population than in the Indian Knoll group at a highly statistically significant level. Forty-five discrete areas of articular surface on each individual skeleton were examined bilaterally and the results compared between the two populations. The bone and joint components were combined into bone and joint totals and the resultant figure compared between populations.

The symmetry of bilateral involvement was generally consistent with the males of Averbuch exhibiting an equal or higher percentage of symmetry than the females. The Indian Knoll males exhibited more symmetry in the knee and shoulder while the females displayed more in the hip and elbow. The lowest rate of symmetry was the female knee at Averbuch with 60%, the highest rate was 100% for both the male knee and male hip at Averbuch. The other percentages of symmetry ranged from 82% to 93%; these are discussed in Chapters V through VIII.

With all agegroups, sexes, and sides combined, the original variables, with the exceptions of the two scapular components, all displayed a higher degree of osteoarthritic involvement among the Averbuch population at the highly statistically significant level p=.00. The bone and joint totals are summarized below.

The means of the total joint scores of the knee, hip, and elbow for Averbuch were all statistically significantly higher than the means of Indian Knoll; only the mean of the total shoulder joint was less highly statistically significant.

Definite differences in the patterning of degenerative joint disease by sex within the two populations were found. Utilizing the same one-way nonparametric analysis of variance program and classifying for the variable sex, the Averbuch group showed no significant difference in the means between the sexes for the knee or the elbow. The differences between the means of the hip and the shoulder are statistically significant with the males exhibiting a higher mean. This is true also in the Indian Knoll sample with the males exhibiting a higher mean. Indian Knoll, however, showed a highly significant statistical difference in the knee, hip, and shoulder but no significant difference in the elbow.

The results of this investigation are delineated in several ways; by percentage of involvement, by statistical probabilities, by total sample, by sex, by agegroup, by side, by symmetry, and by pattern of involvement. With the reburial of archaeological collections a distinct possibility in the future, all possible data must be collected and presented for the utilization of future researchers as well as those in the present scientific pool.

The patterns of involvement and the severity of degenerative changes appear to reflect differences in the activity patterns within the populations examined. The women of both samples utilized the arm and shoulder in similar fashions with a greater intensity of activity compounded by biocultural stress at Averbuch. The males exhibited a similar pattern in the elbow; however, the Averbuch males exhibited a highly significant increase in skeletal disruption in the other large joints. The customary activities of the Averbuch individuals may have been exacerbated by fighting on rough terrain and attempting agricultural activities on marginally productive land in addition to coping with social and nutritional stress.

Current research concurs with the findings of this report that the Averbuch population utilized the skeletal frame in a more stressful manner than the Indian Knoll population (Goldsmith, 1987, personal communication).

Future research strategies which are critical to the understanding of the socioeconomic organization of Averbuch include the reconstruction of activity patterns to determine the degree of reliance on hunting and gathering in addition to agriculture; a focus on vertebral osteophytosis and patterns of involvement correlated with cultural activities both of occupation and recreation; and the utilization of newer methods of skeletal analysis, not only macroscopic but also microscopic and chemical, to reconstruct the diet.

Once the place of the Averbuch people within the framework of the Middle Mississippian Phase as a whole is found, that strong foundation will be the basis of further extrapolation incorporating the small sites which abound in Middle Tennessee.

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APPENDICES

APPENDIX A

List of Variables

TLCT = tibia lateral condylar tubercle
TMCT = tibia medial condylar tubercle
TPCL = tibia insertion of posterior cruciate ligament
TLLB = tibia marginal lipping, lateral border
TLMB = tibia marginal lipping, medial border
TLAS = tibia lateral articular surface
TMAS = tibia medial articular surface
FTL = distal femur transverse lipping
FMCL = distal femur marginal condylar lipping
FNL = distal femur intercondylar notch lipping
FLCS = distal femur lateral condylar surface
FMCS = distal femur medial condylar surface
FPS = distal femur patellar surface
PDL = patella dorsal lipping
PVL = patella ventral lipping
PAS = patella articular surface
FLT = proximal femur pit for ligamentum teres
FLH = proximal femur marginal lipping around head
FIL = proximal femur intertrochanteric line
FTF = proximal femur trochanteric fossa
FASS = proximal femur articular surface shape
FASC = proximal femur articular surface condition
AR = acetabulum rim
AF = acetabulum fossa
AAS = acetabulum articular surface
AIL = iliofemoral ligament insertion
HMLH = proximal humerus marginal lipping of head
HT = proximal humerus greater and lesser tubercles
HAS = proximal humerus articular surface
SMLG = scapula marginal lipping of glenoid
SAS = scapula articular surface
HTMM = distal humerus trochlea medial margin
HLTR = distal humerus lateral trochlear ridge
HOF = distal humerus olecranon fossa
HCF = distal humerus coronoid fossa
HAST = distal humerus articular surface trochlea

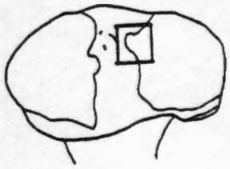
HASC = distal humerus articular surface capitulum
UCML = ulna coronoid process marginal lipping
UOML = ulna olecranon process marginal lipping
URML = ulna radial facet marginal lipping
UASC = ulna articular surface coronoid process
UA = ulna articular surface olecranon process
UASR = ulna articular surface radial facet
RSSH = radius superior surface of head
RIMH = radius inferior margin of head

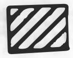
APPENDIX B.

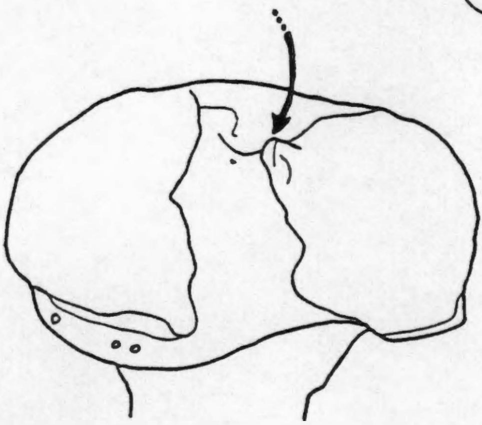
Illustrations and Scoring Methodology

PROXIMAL TIBIA

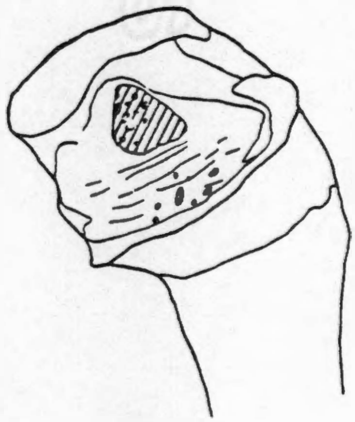
A. Lateral Condylar Tubercle



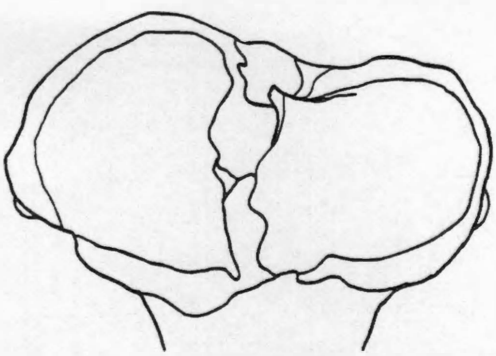
 = eburnation



0. Rounded



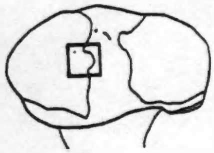
2. Obliterated by eburnation



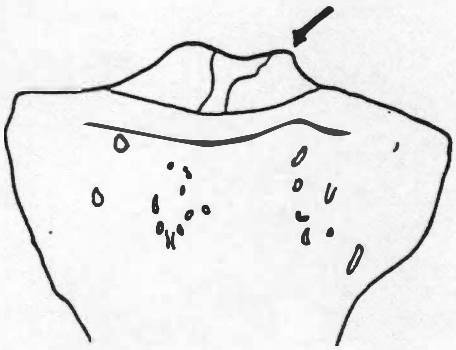
1. Pointed spicule

PROXIMAL TIBIA

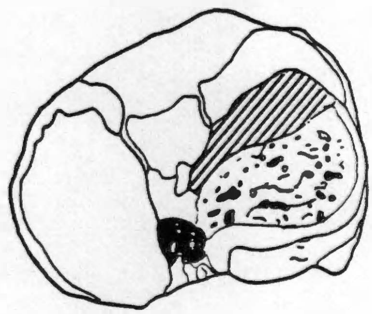
B. Medial Condylar Tubercle



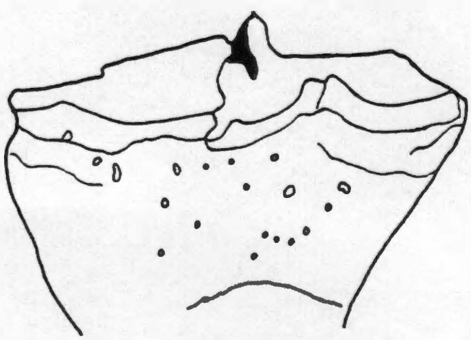
= eburnation



0. Rounded



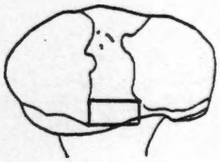
2. Obliterated by eburnation

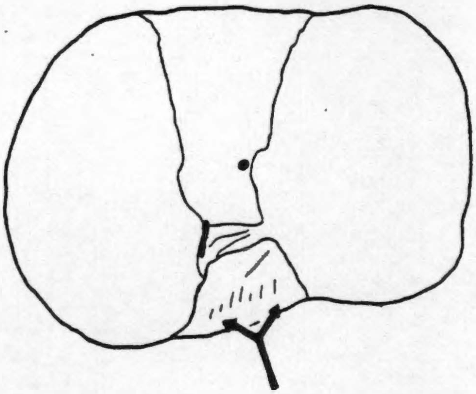


1. Pointed spicule

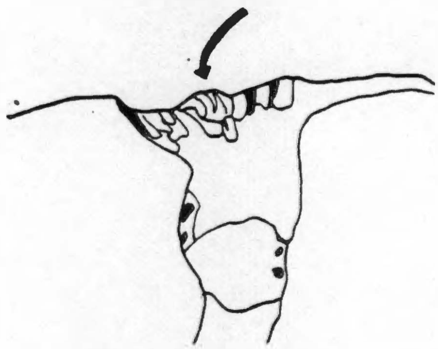
PROXIMAL TIBIA

C. Insertion of the Posterior Cruciate Ligament

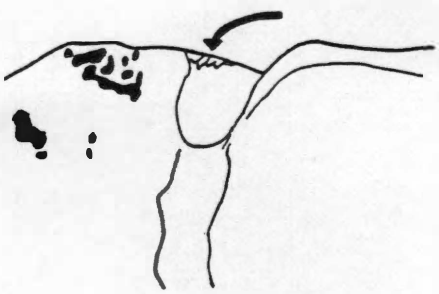




0. Smooth



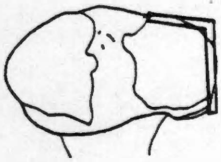
2. Deep excavation with spicules 50% of area

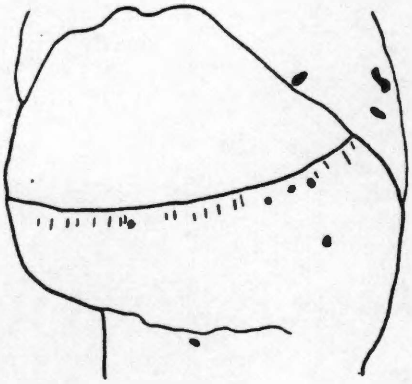


1. Some excavation with some spicules

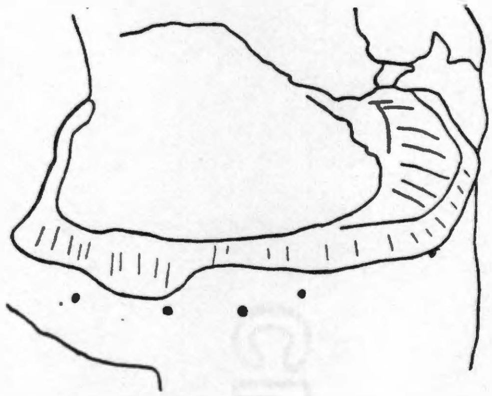
PROXIMAL TIBIA

D. Marginal Lipping of Lateral Border

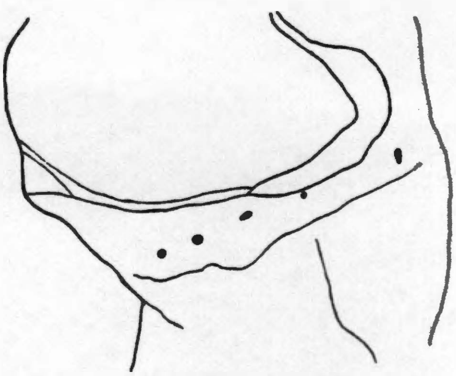




0. No lipping



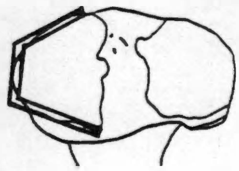
2. Pronounced lipping

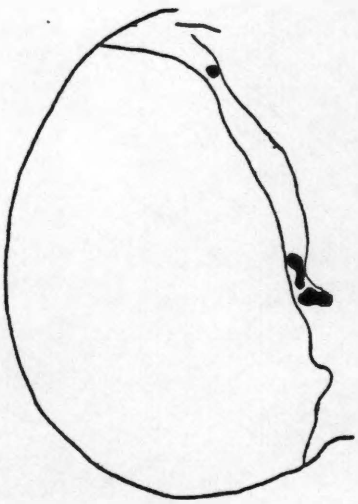


1. Some lipping

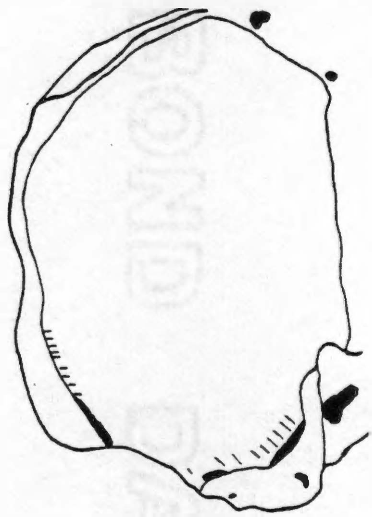
PROXIMAL TIBIA

E. Marginal Lipping of Medial Border





0. No lipping

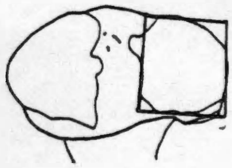


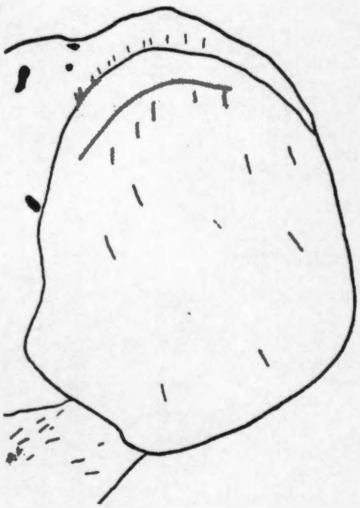
2. Pronounced lipping

1. Some lipping

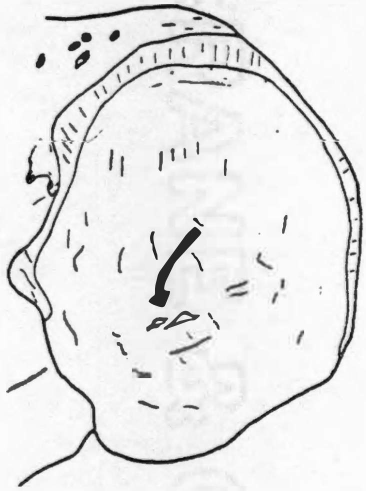
PROXIMAL TIBIA

F. Lateral Articular Surface

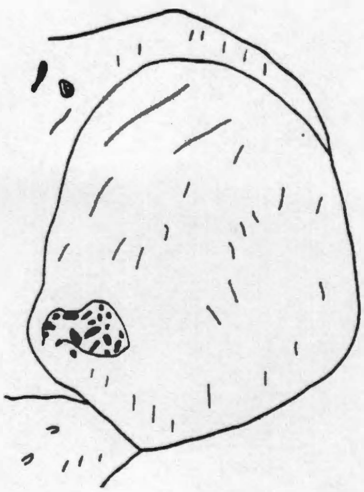




0. Smooth



1. Slight disruption

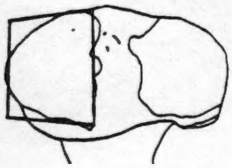


2. Area of pitting

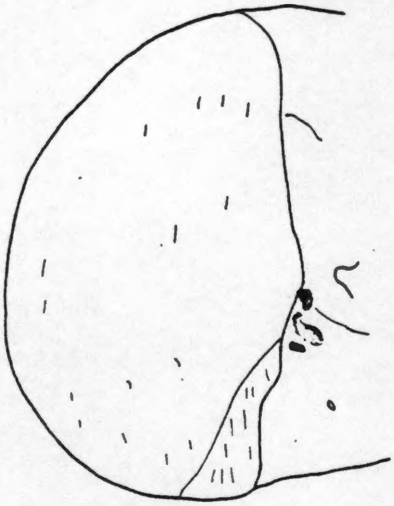
3. Pitting/eburnation
20% of surface

PROXIMAL TIBIA

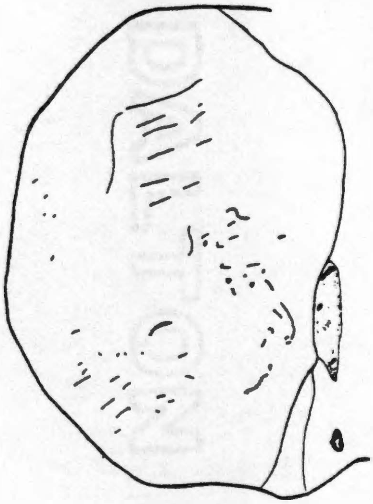
G. Medial Articular Surface



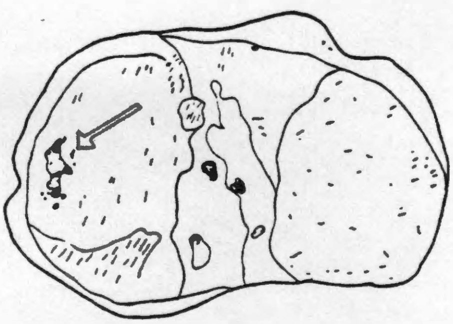
 = eburnation



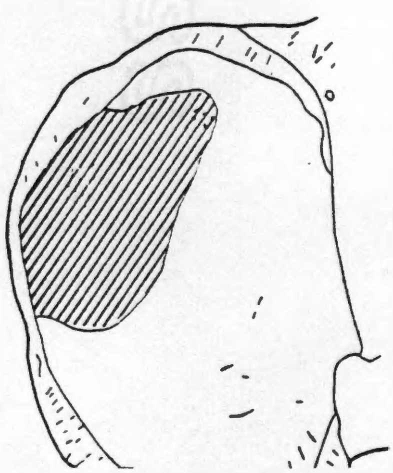
0. Smooth



1. Slight disruption



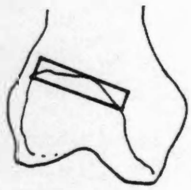
2. Pitted or
eburnated

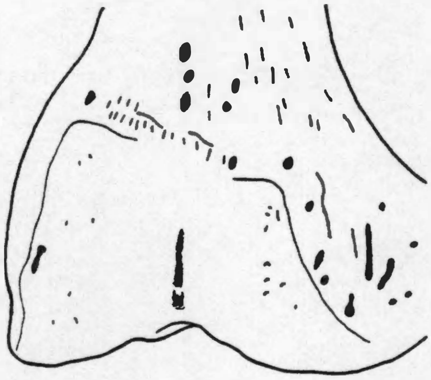


3. Pitted or eburnated
25% of surface

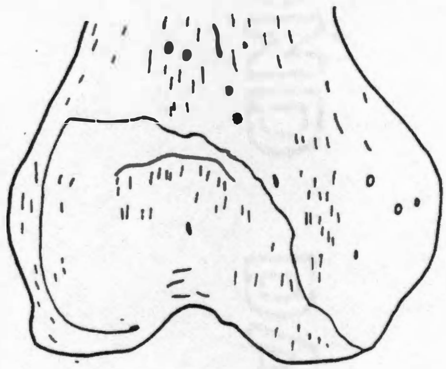
DISTAL FEMUR

A. Transverse Lipping

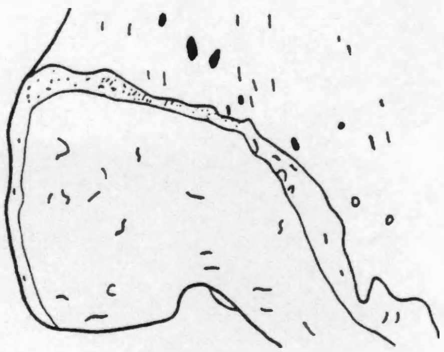




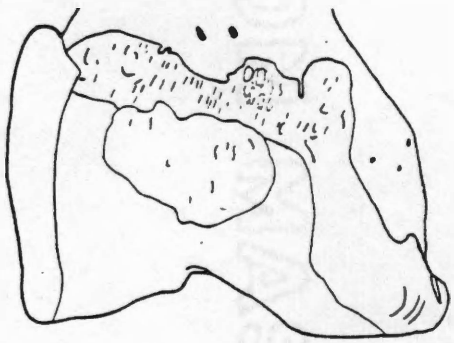
0. No lipping



1. Slight lipping



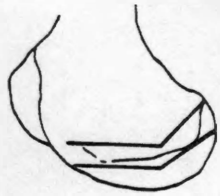
2. Moderate lipping

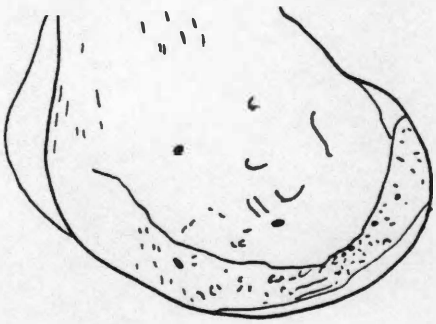


3. Distinct lip
>50% of length

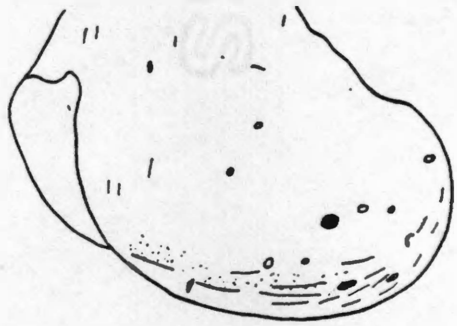
DISTAL FEMUR

B. Marginal Condylar Lipping

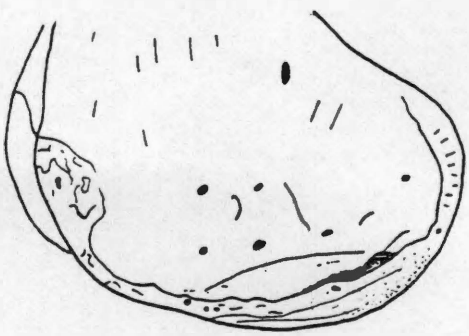




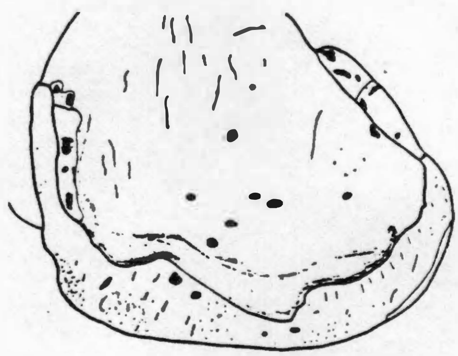
0. No lipping



1. Some sharp edge



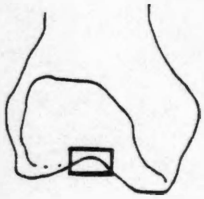
2. Raised edge

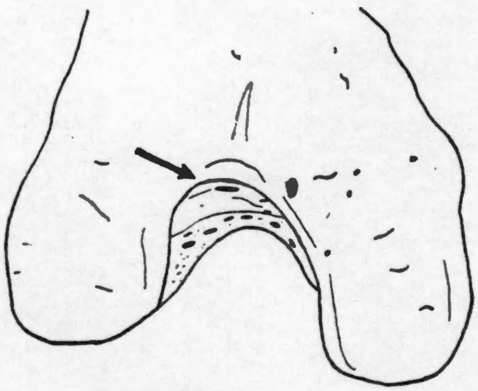


3. Buildup with trough between surface and lip

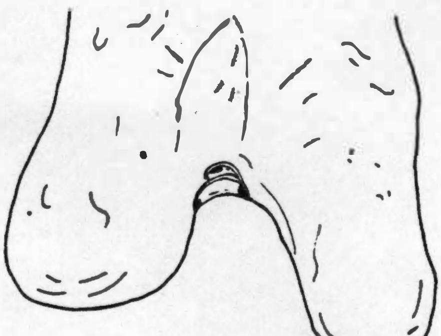
DISTAL FEMUR

C. Intercondylar Notch Lipping

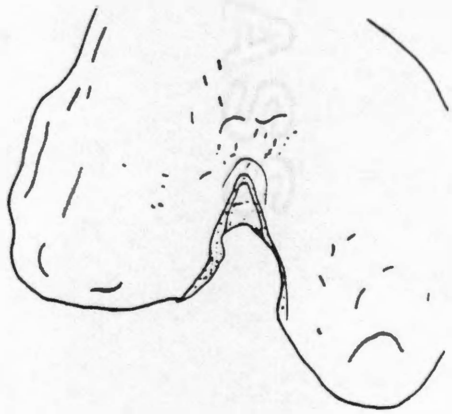




0. Smooth



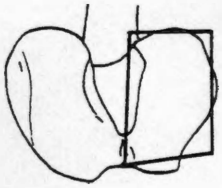
1. Slight lip



2. Sharp lip

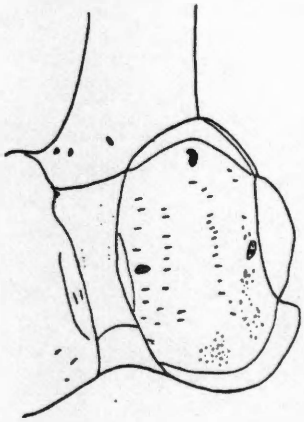
DISTAL FEMUR

D. Lateral Condylar Surface

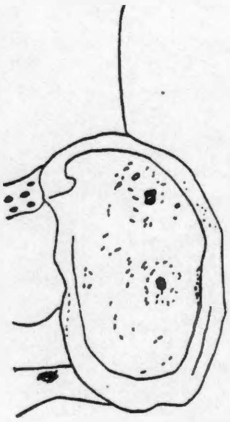


 = eburnation

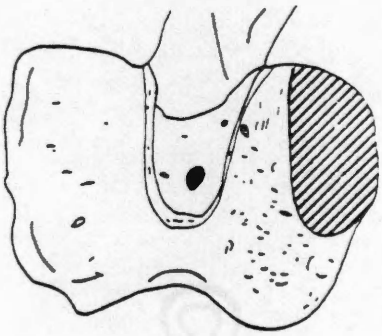
0. Smooth



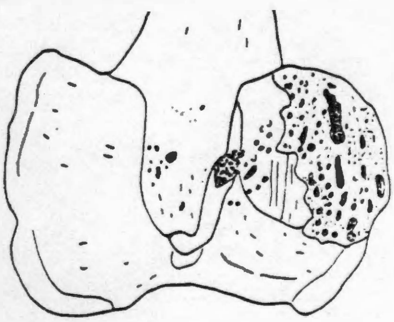
1. Slight disruption



2. Pitting <50% of
   surface / accretions
   50% of surface



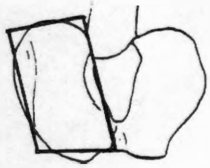
3. Severe eburnation 50%
   of surface

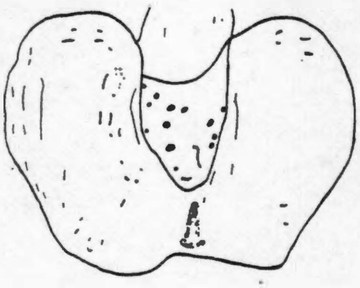


4. Destruction of surface

DISTAL FEMUR

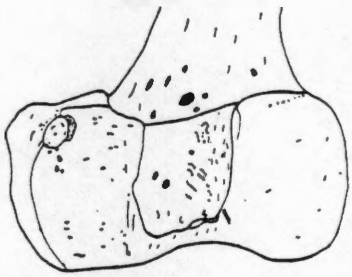
E. Medial Condylar Surface



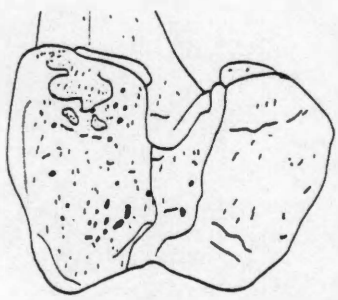


0. Smooth

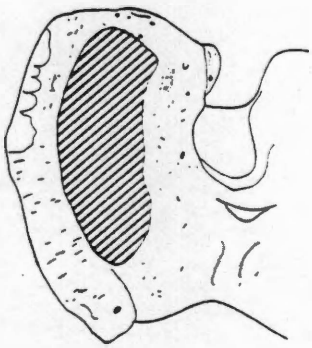
= eburnation



1. Slight disruption



2. Pitting <50% of
surface / accretions
50% of surface

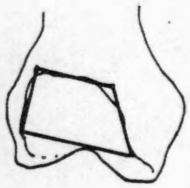


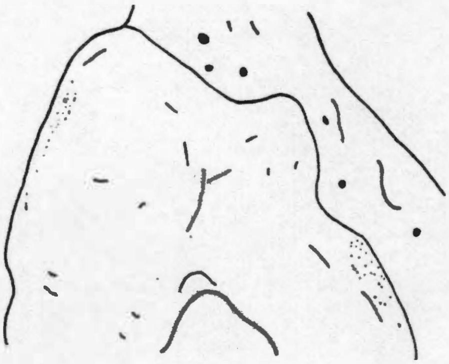
3. Severe eburnation 50%
of surface

4. Complete destruction
of surface

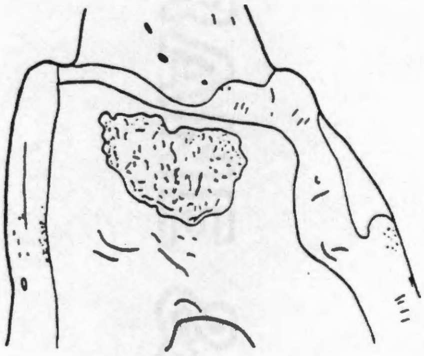
DISTAL FEMUR

F. Patellar Surface

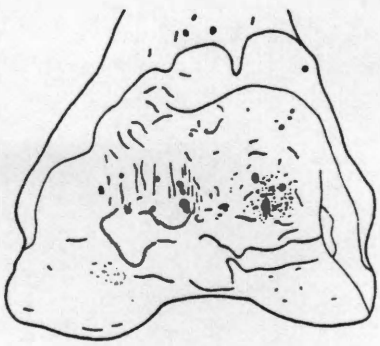




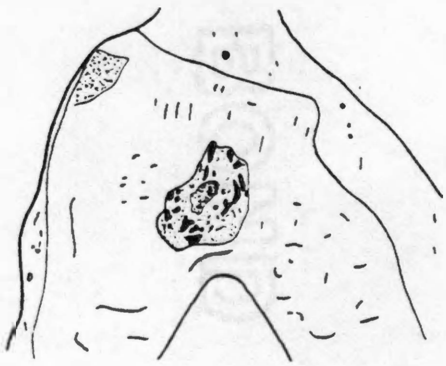
0. Smooth



1. Small irregularities



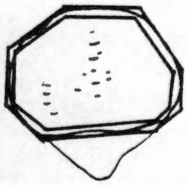
2. Pitting, eburnation or major disruption

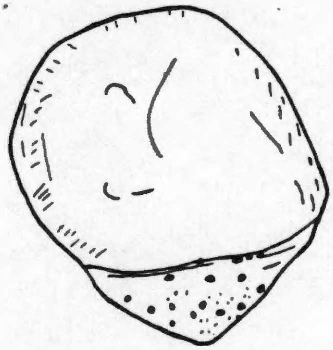


3. Destruction of 50% of surface

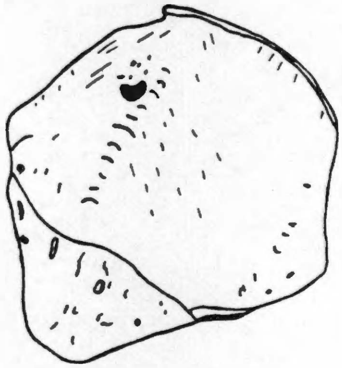
PATELLA

A. Dorsal Lipping

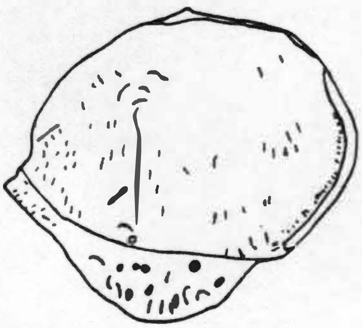




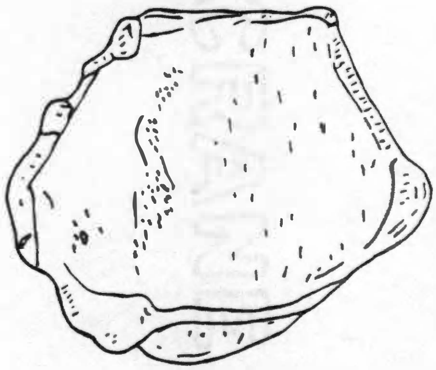
0. Smooth



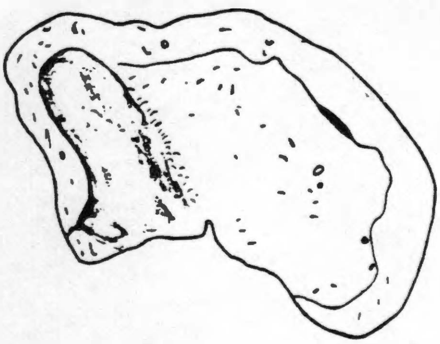
1. Visible lip



2. Sharp raised lip



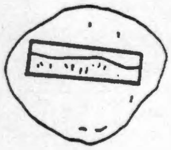
3. Lipping 50% of circumference

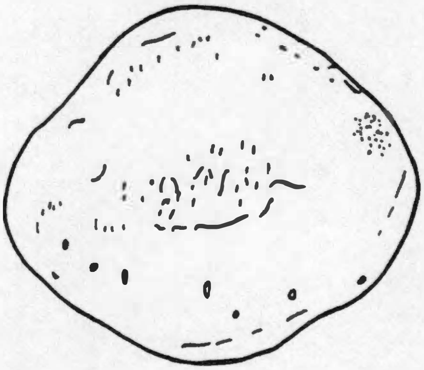


4. Lip >50% size of original surface

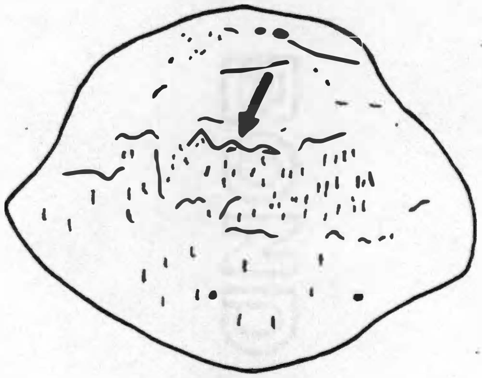
PATELLA

B. Ventral Lipping

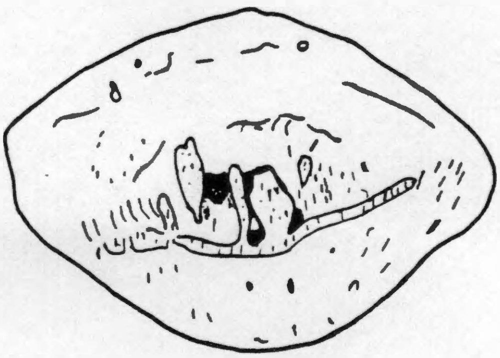




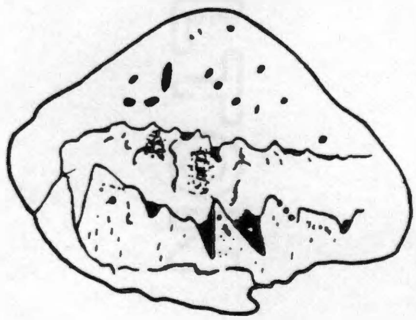
0. Smooth



1. Small areas of spicules



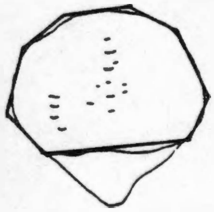
2. Sharp spicules 25-50% of surface

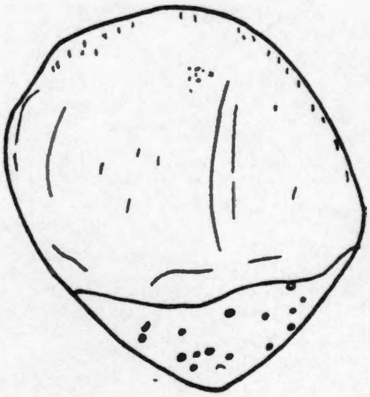


3. Sharp spicules 50% of surface

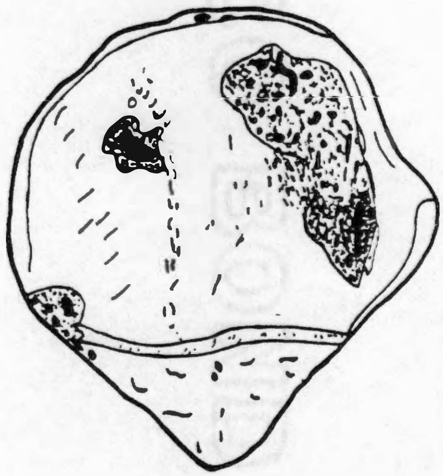
PATELLA

C. Articular Surface

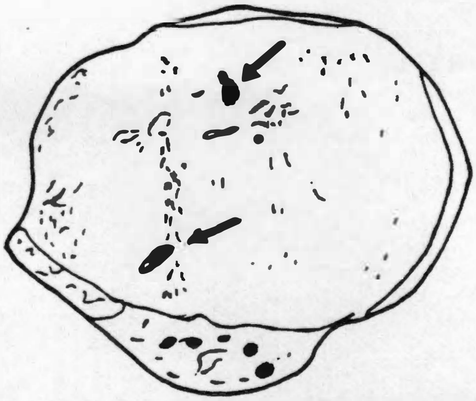




0. Smooth



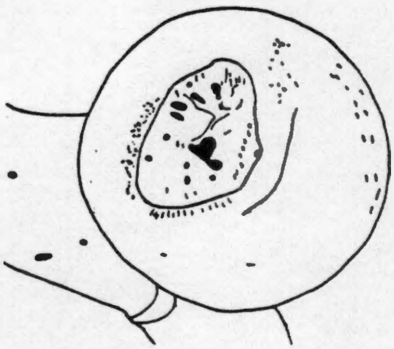
2. Deeply pitted or eburnated surface



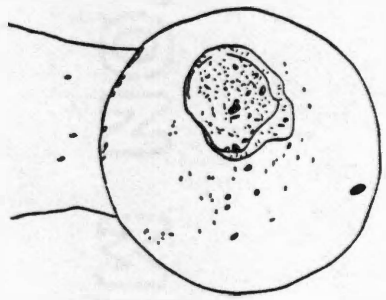
1. Small areas of irregularities

PROXIMAL FEMUR

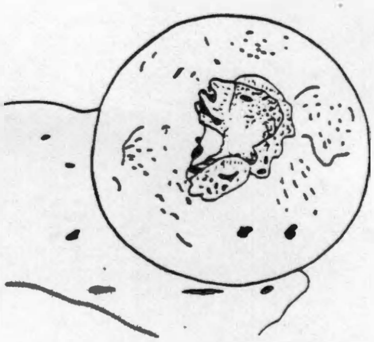
A. Lipping around Fovea Capitis



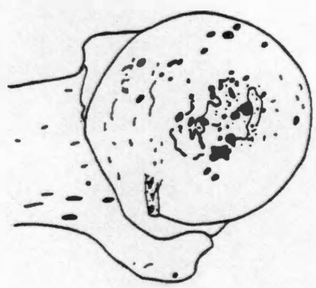
0. Rounded edge



1. Slight lipping



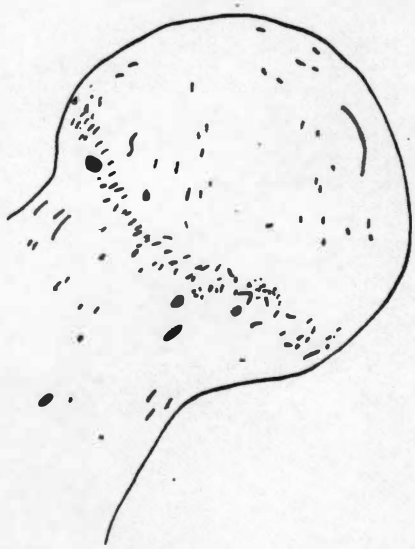
2. Sharp lipping



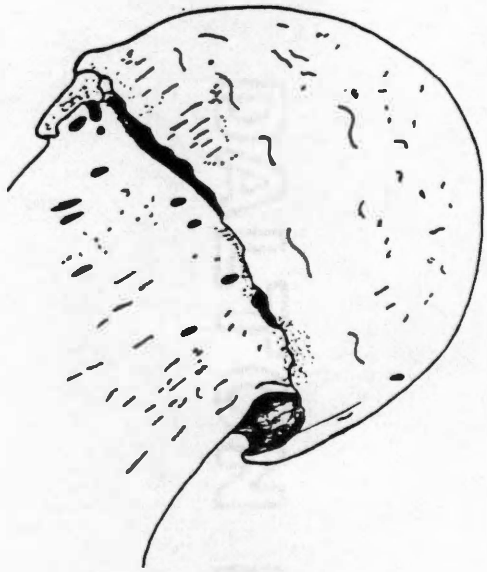
3. Completely obliterated

PROXIMAL FEMUR

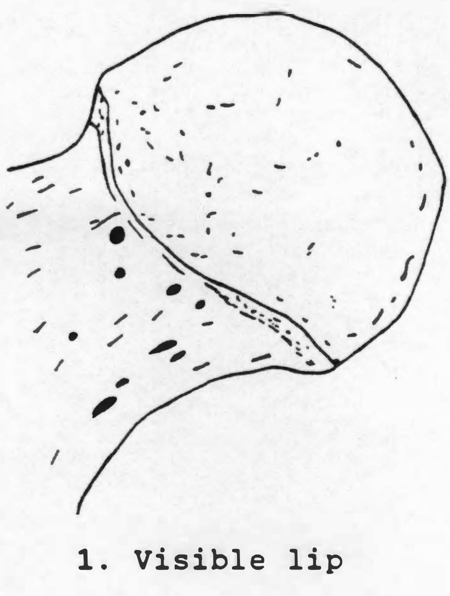
B. Marginal Lipping around Head



0. Smooth



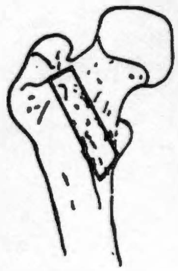
2. Sharp edge



1. Visible lip

PROXIMAL FEMUR

C. Remodeling of Intertrochanteric Line



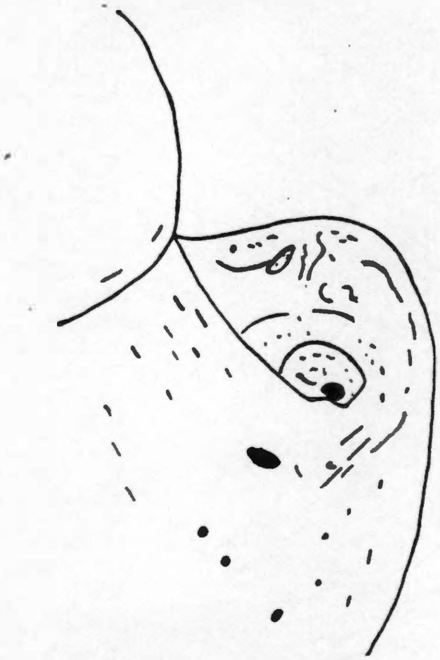
0. Smooth

2. Sharply raised with
much roughness

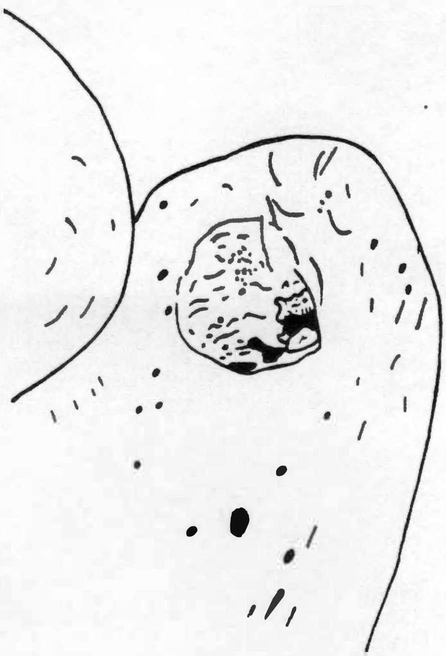
1. Raised with small degree
of roughness

PROXIMAL FEMUR

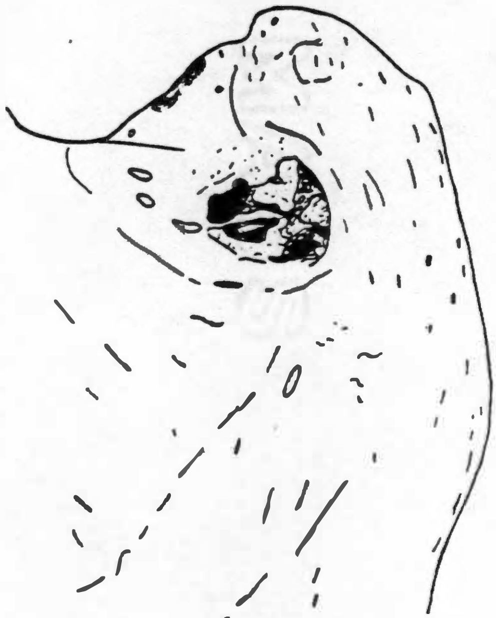
D. Remodeling of Trochanteric Fossa



0. Walls sharp and smooth

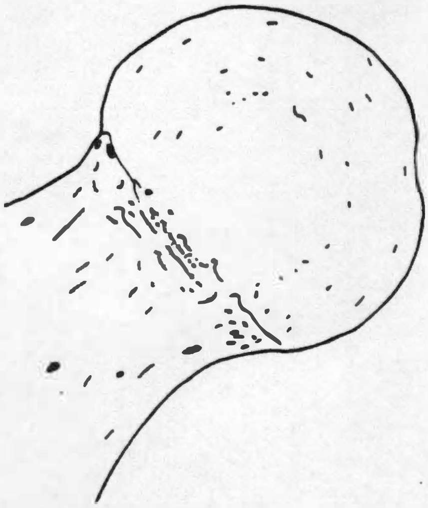


1. Some bony spicules

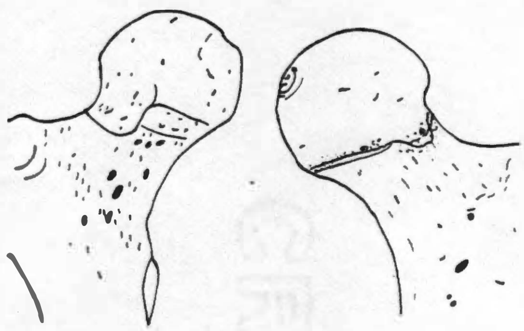


2. Sharp spicules 50%
of fossa

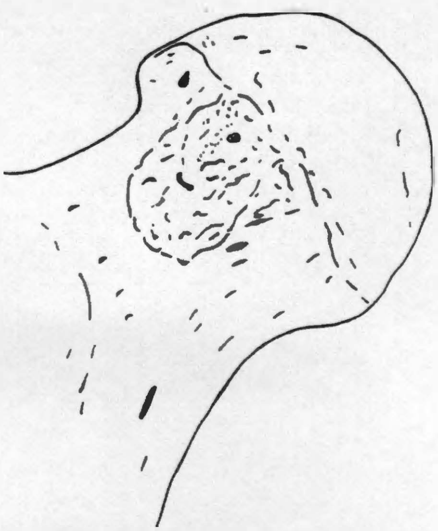
E. Shape of the Articular Surface on the Head



0. Normal shape



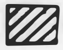
2. Extended on to neck on both sides

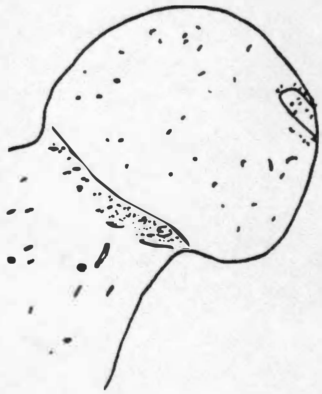


1. Defined extension

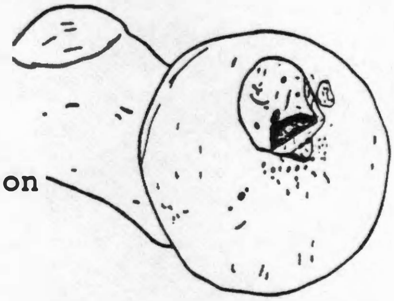
PROXIMAL FEMUR

F. Condition of the Articular Surface on the Head

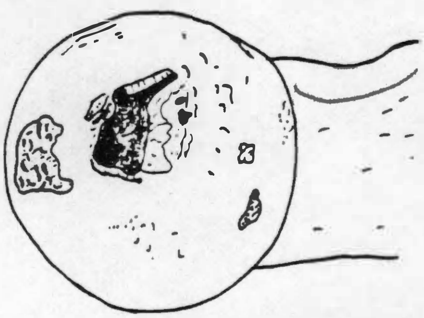
= eburnation



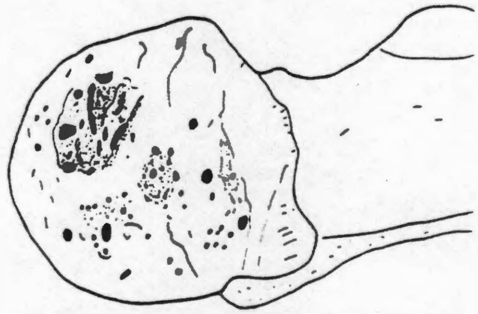
0. Smooth



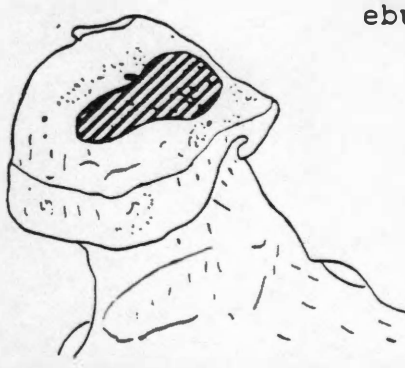
1. Small areas of irregularities



2. Large areas of pitting or accretions



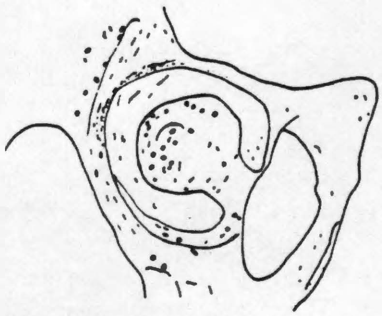
3. Severe pitting or accretions / slight eburnation



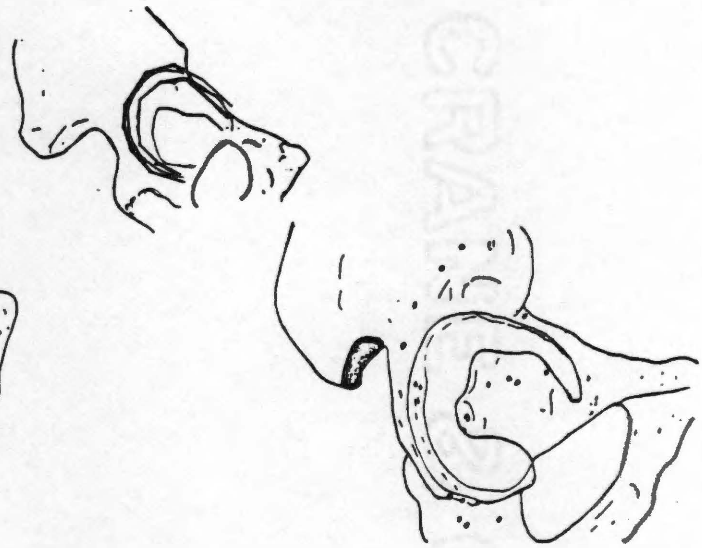
4. Eburnation 10% or destruction on 50% of surface

ACETABULUM

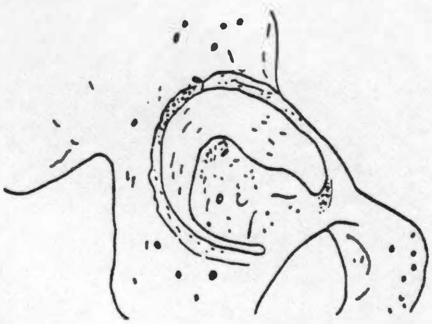
A. Remodeling of Rim



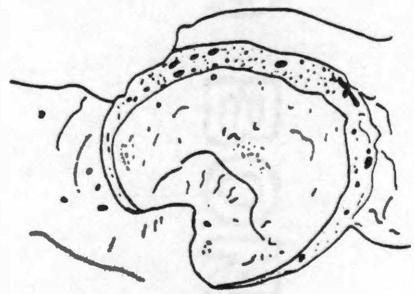
0. Smooth



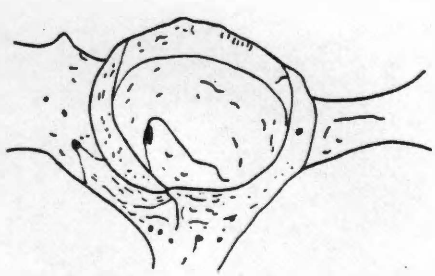
1. Buildup or thickening



2. Sharp buildup



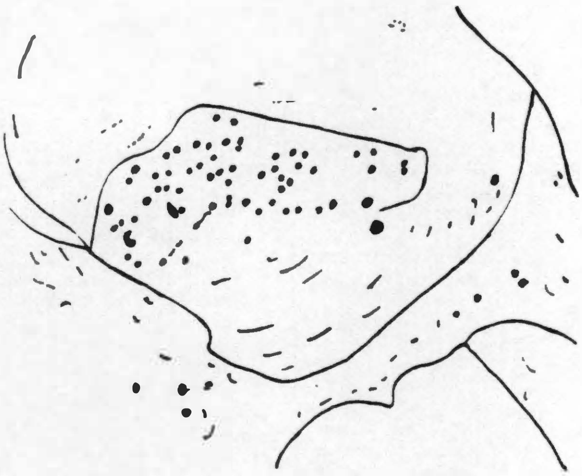
3. Lipping 2mm anywhere



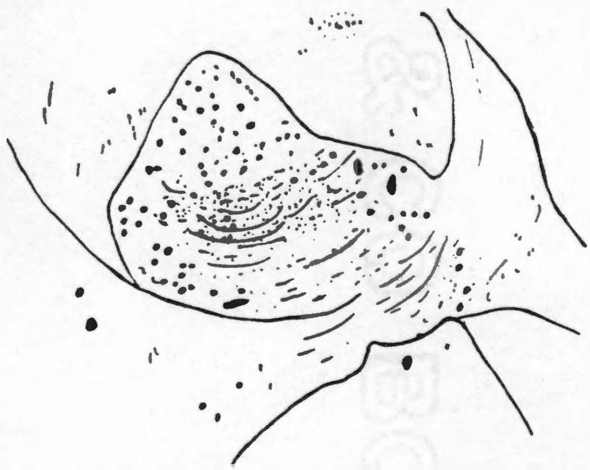
4. Lipping 25% of circumference

ACETABULUM

B. Fossa



0. Smooth

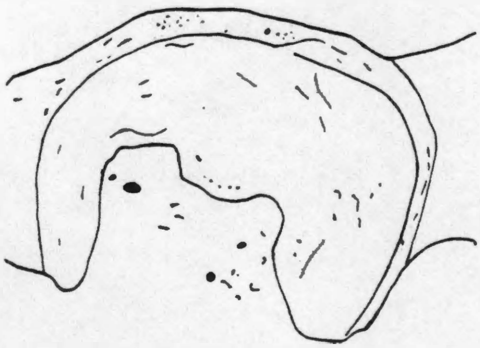


1. Deep concavity

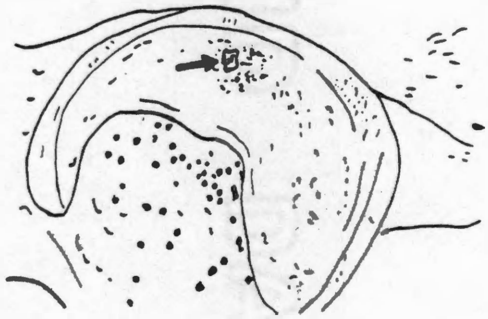
ACETABULUM

C. Surface

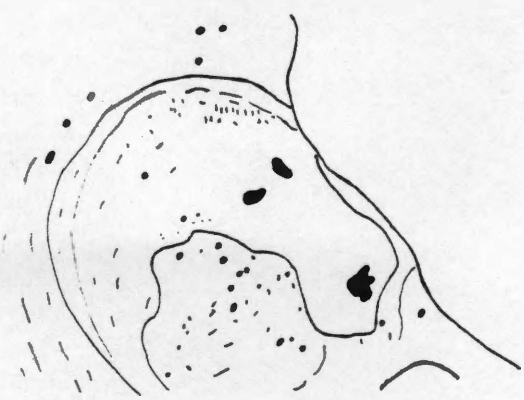
= eburnation



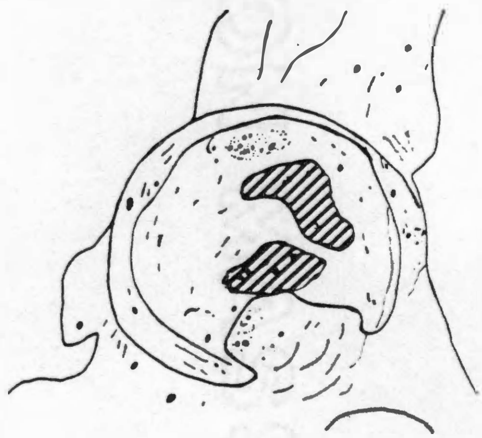
0. Smooth



1. Small irregularities

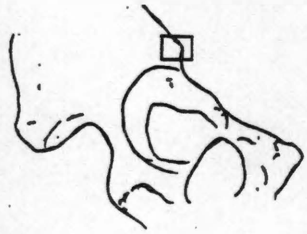


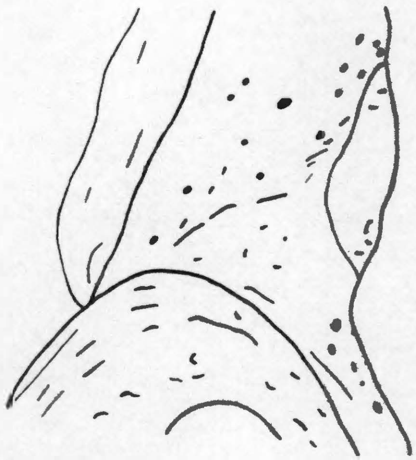
2. Large accretions or
areas of pitting



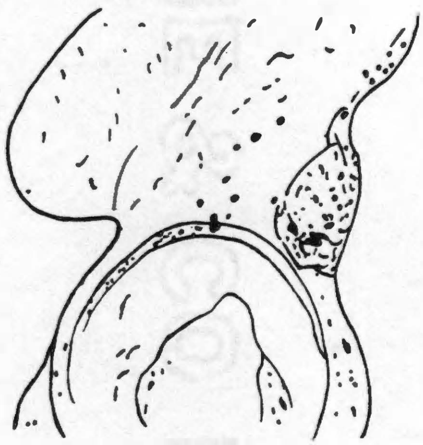
3. Pitting 25% of
surface or eburnation

D. Condition of Iliofemoral Area

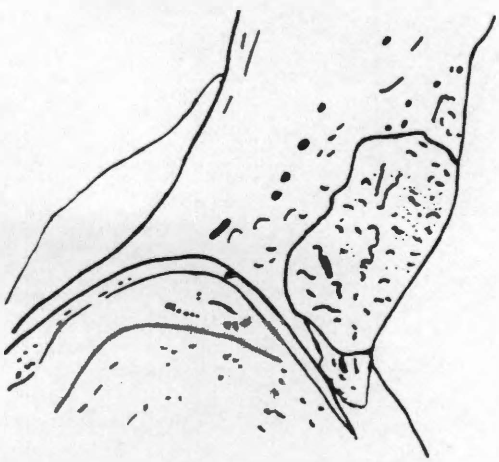




0. Smooth



2. Great deal of buildup and deep irregularities

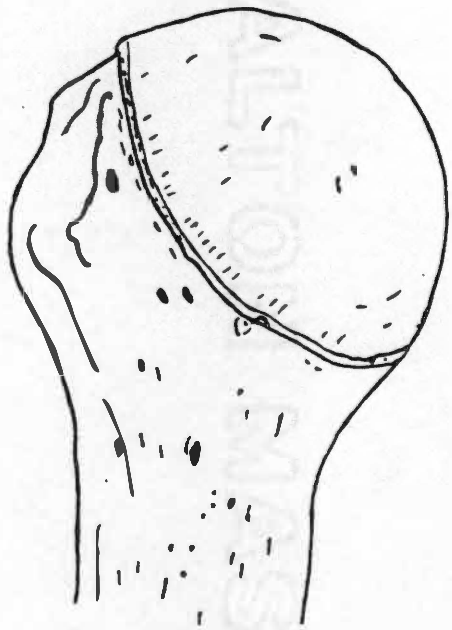


1. Bony buildup

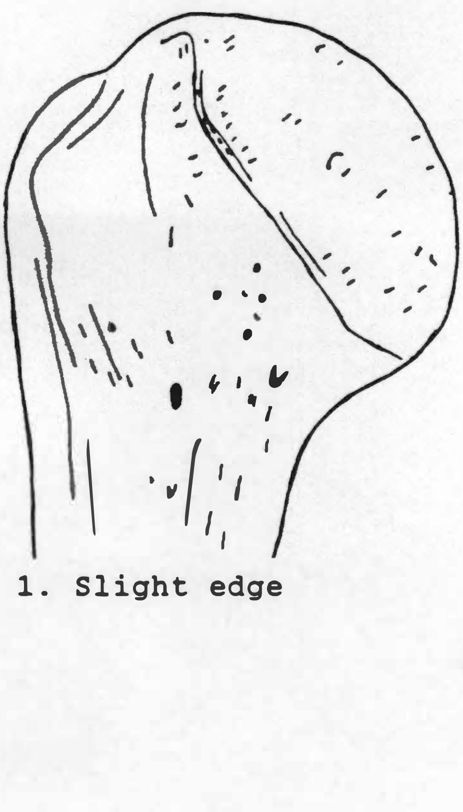
PROXIMAL HUMERUS

A. Marginal Lipping of Head

0. Smooth



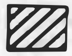
2. Sharp edge 50% of circumference

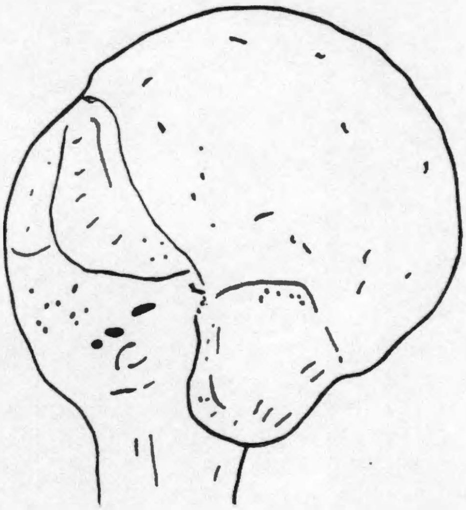


1. Slight edge

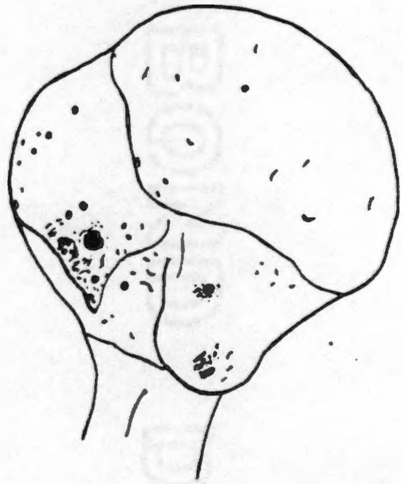
PROXIMAL HUMERUS

B. Remodeling on the Greater and Lesser Tubercles

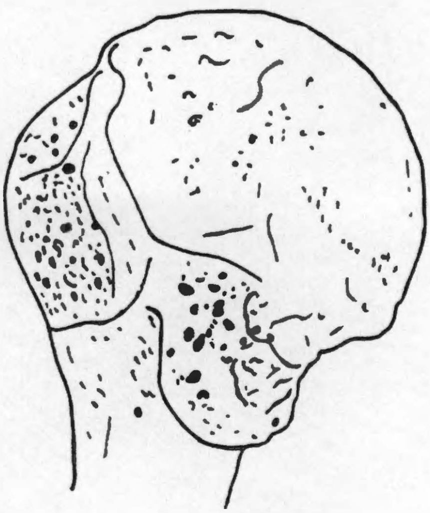
 = eburnation



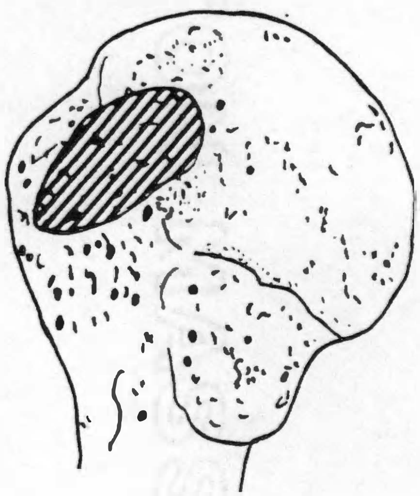
0. Smooth



1. Some buildup or excavation



2. Sharp spicules

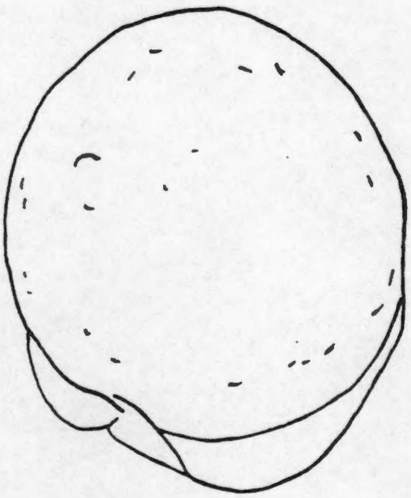


3. Covered by irregularities or eburnation

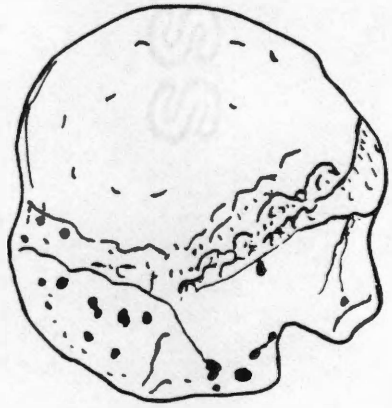
PROXIMAL HUMERUS

C. Articular Surface of Head

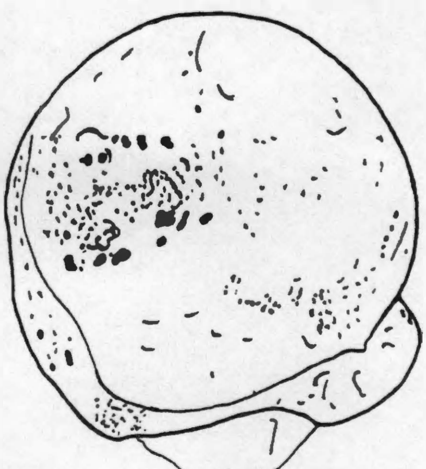
= eburnation



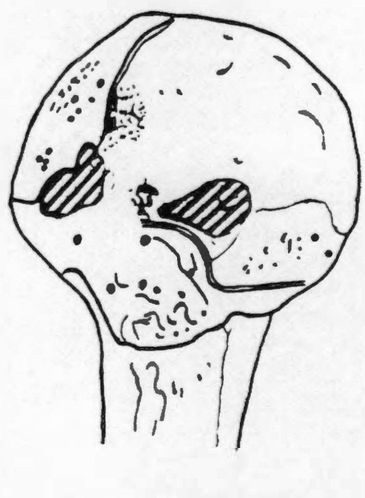
0. Smooth



1. Bony accretions or areas of pitting



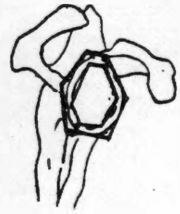
2. Pitting or bony accretions 25% of surface

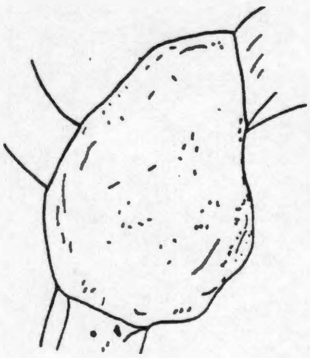


3. Eburnation

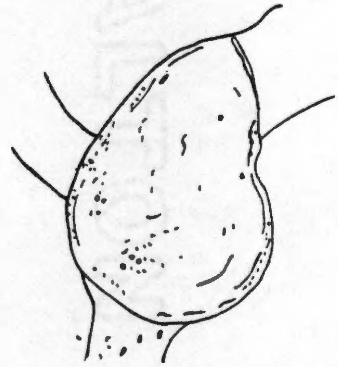
SCAPULA

A. Marginal Lipping of Glenoid

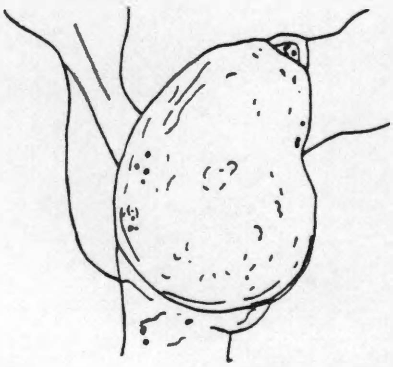




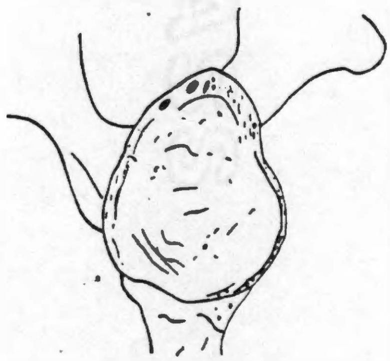
0. Smooth



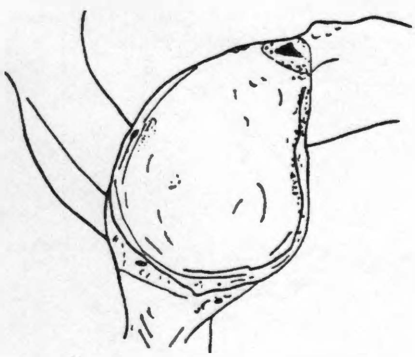
1. Some buildup



2. Sharp edge



3. Sharp edge 50%
of circumference

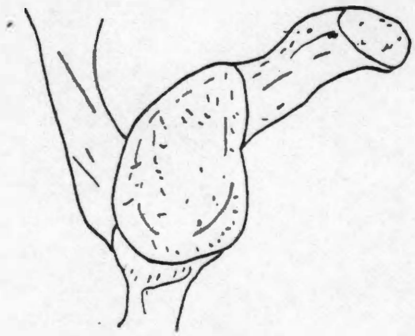


4. Lip of 2mm

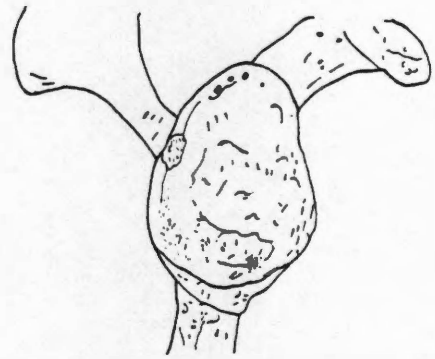
SCAPULA

B. Glenoid Articular Surface

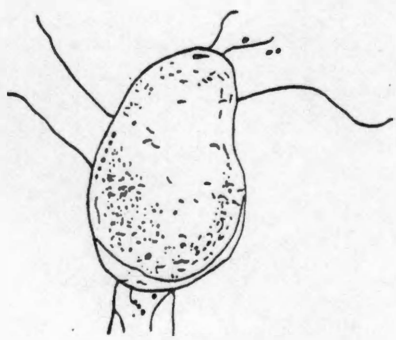
 = eburnation



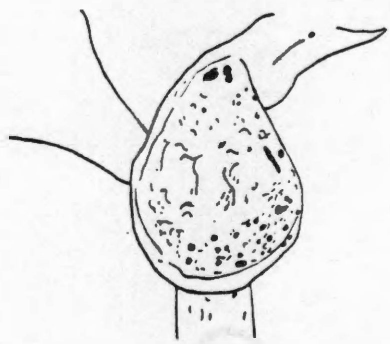
0. Smooth



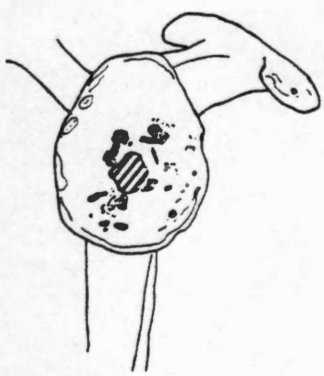
1. Small pitting or accretions



2. Pitting or bony accretions <25% of surface



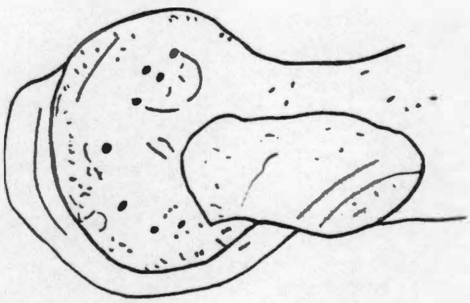
3. Severe pitting 25% of surface



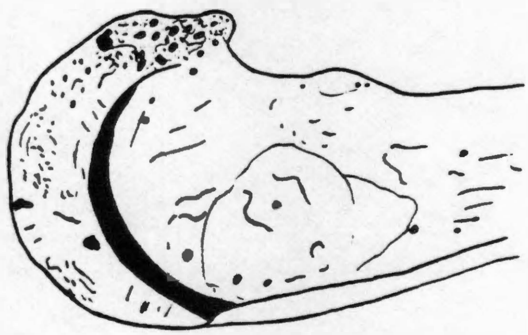
4. Pitting or eburnation 50% of area

DISTAL HUMERUS

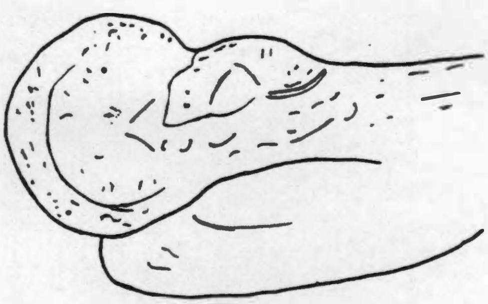
A. Trochlea Medial Margin



0. Smooth



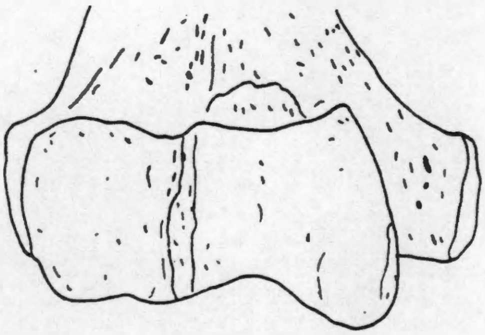
2. Edge excavated to form trough 50% of length



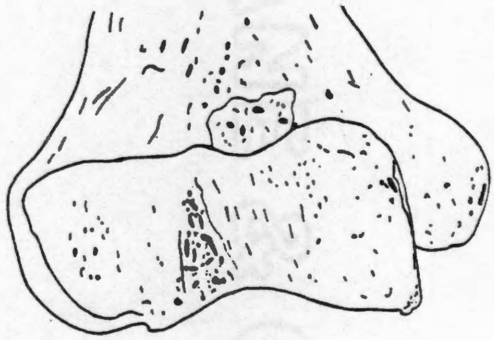
1. Visible edge

DISTAL HUMERUS

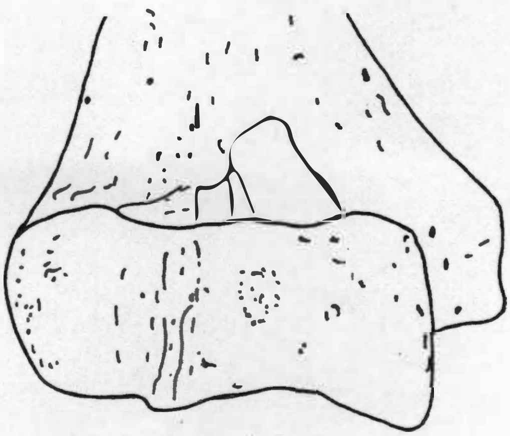
B. Lateral Trochlea Ridge



0. Clear sharp margin



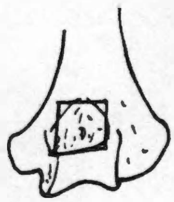
2. Bony accretions or pitting

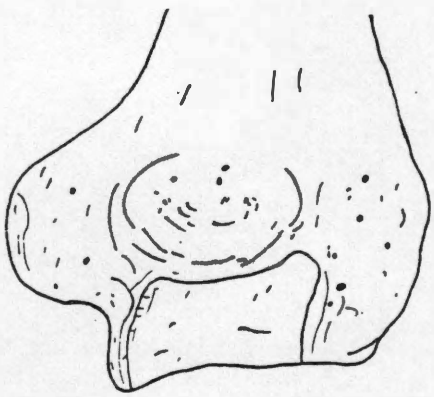


1. Rounded

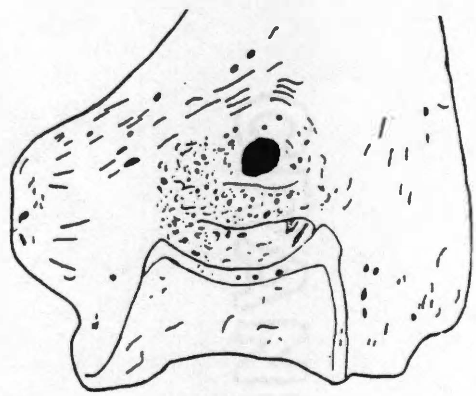
DISTAL HUMERUS

C. Olecranon Fossa

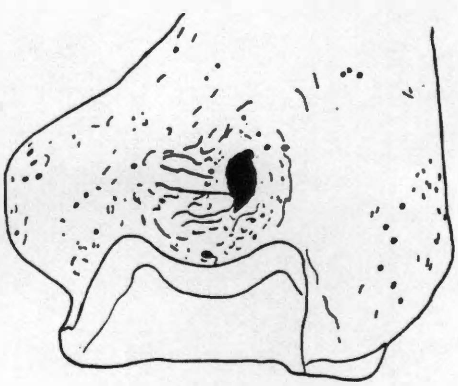




0. Smooth



2. Obliterated

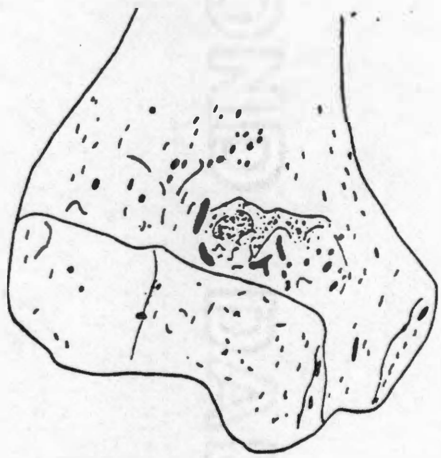


1. Bony spicules and roughness

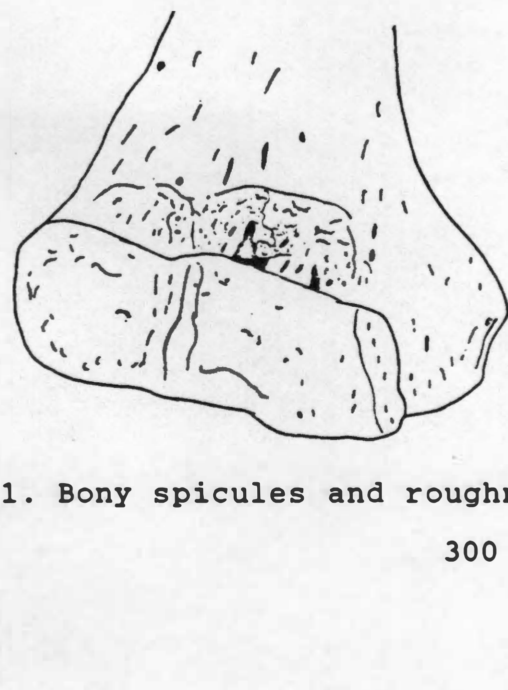
DISTAL HUMERUS

D. Coronoid Fossa

0. Smooth



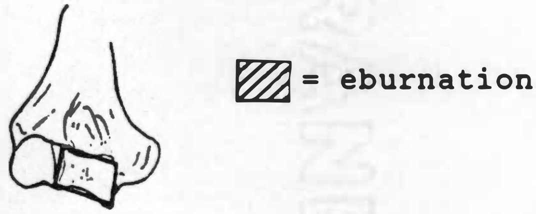
2. Obliterated

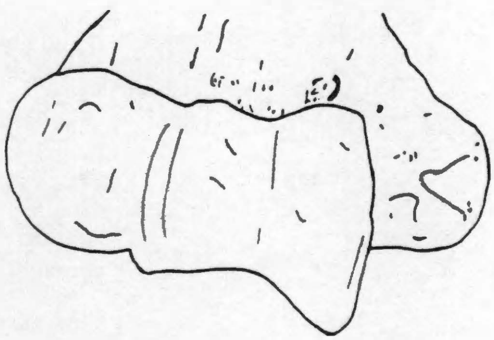


1. Bony spicules and roughness

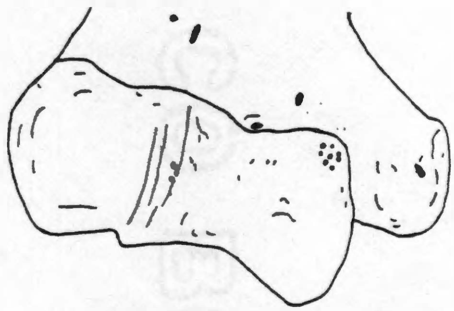
DISTAL HUMERUS

E. Trochlea Articular Surface

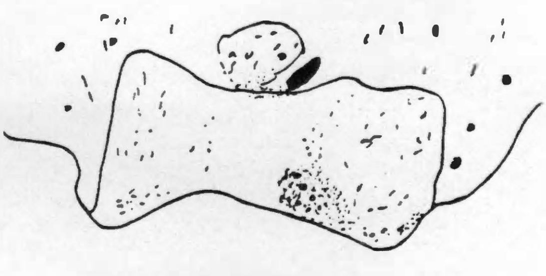




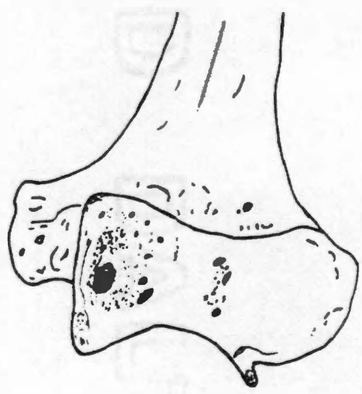
0. Smooth



1. Small areas of pitting



2. Severe pitting
   >10% of surface



3. Eburnation

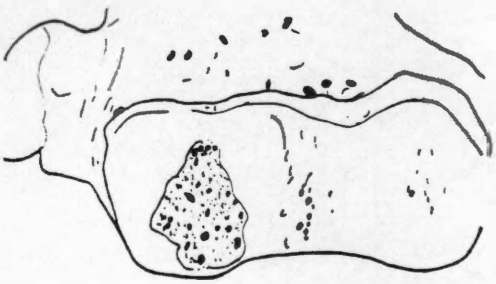
DISTAL HUMERUS

F. Capitulum Articular Surface

= eburnation

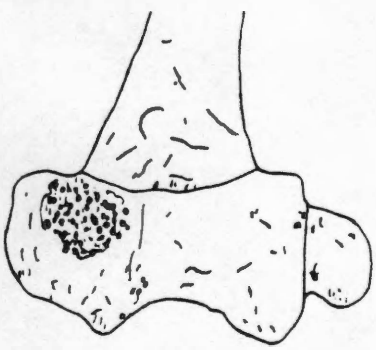
0. Smooth

1. Pitting or bony accretions <25% of surface



2. Pitting or bony accretions 25% of surface

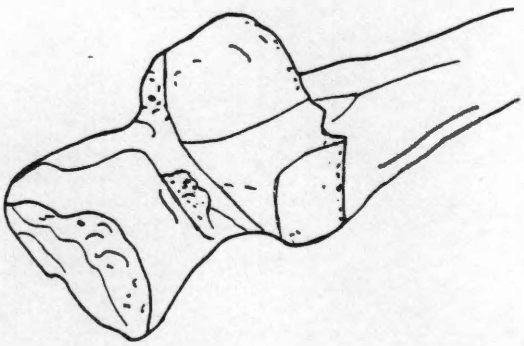
3. Eburnation



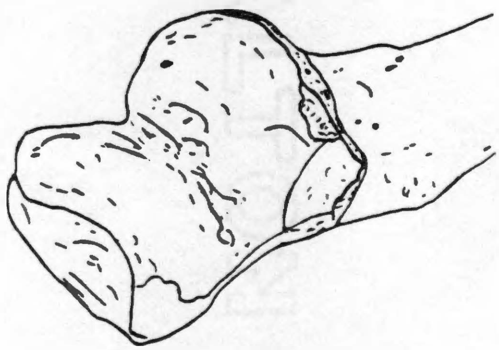
4. Destruction of articular 50% of surface

PROXIMAL ULNA

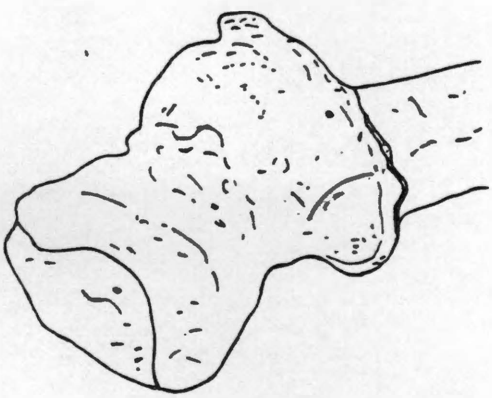
A. Coronoid Lipping Marginal Lipping



0. No lipping



2. Lipping 50% of circumference

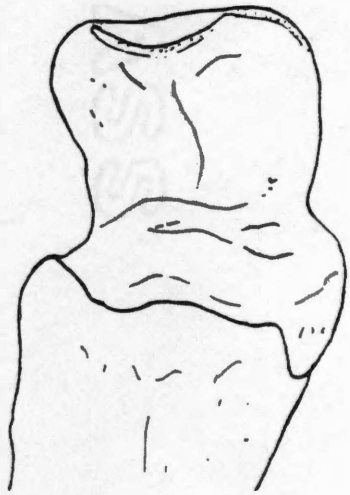


1. Sharp lipping

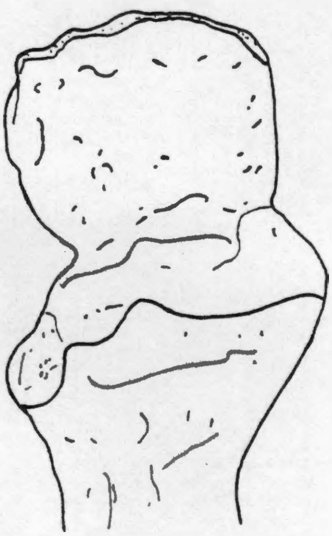
PROXIMAL ULNA

B. Olecranon Process Marginal Lipping

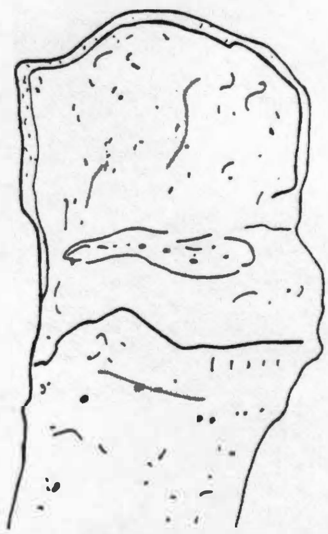
0. No lipping



1. Sharp lipping



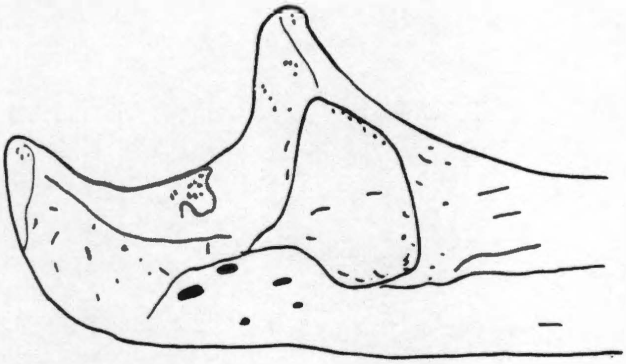
2. Sharp lipping 25% of edge



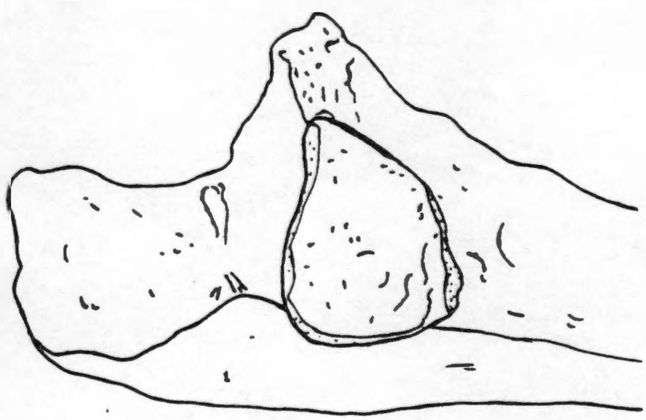
3. Lipping extends onto lateral edge

PROXIMAL ULNA

C. Radial Facet Lipping



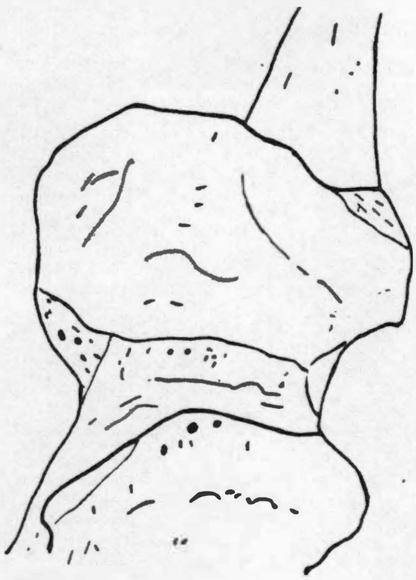
0. Rounded



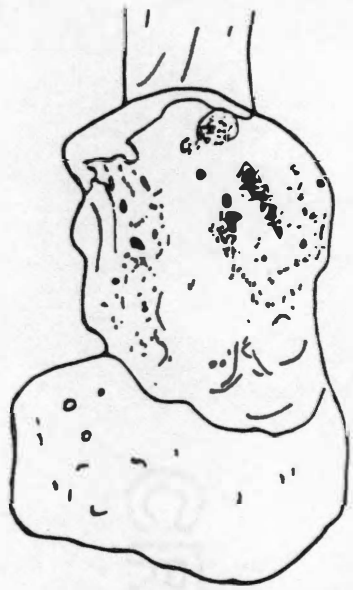
1. Visible lip

PROXIMAL ULNA

D. Coronoid Process Articular Surface



0. Smooth

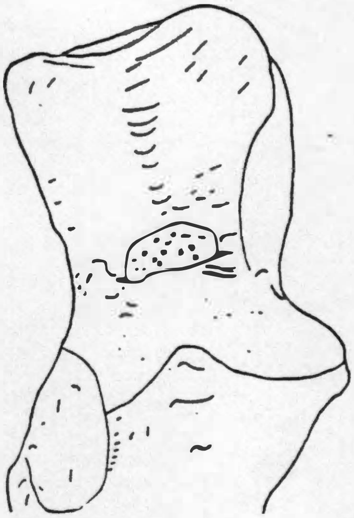


2. Large accretions or pitting
   10% of surface

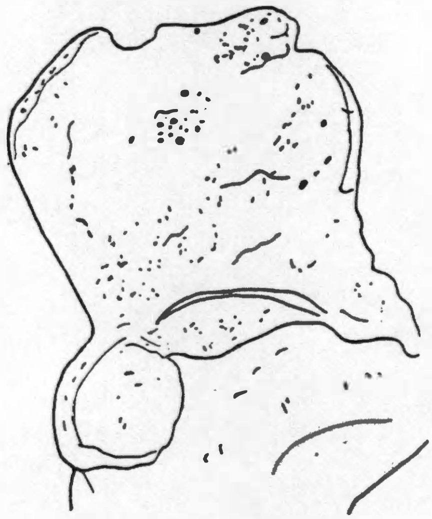
1. Small bony accretions

PROXIMAL ULNA

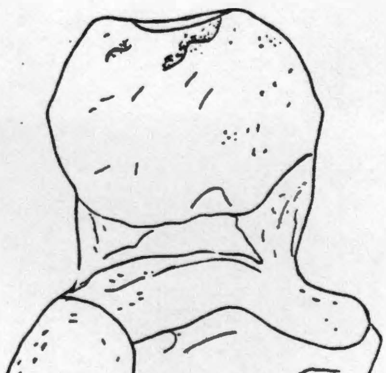
E. Olecranon Process Articular Surface



0. Smooth



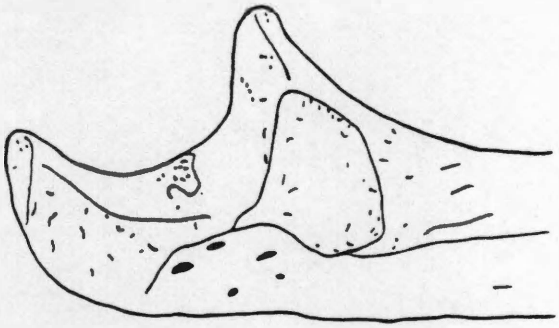
2. Large accretions or pitting 10% of surface



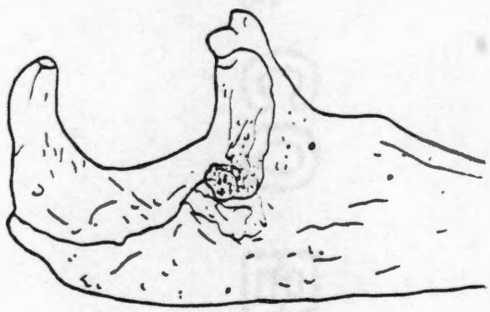
1. Small bony accretions

PROXIMAL ULNA

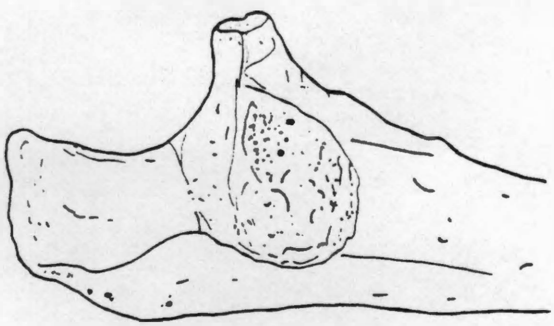
F. Radial Facet Articular Surface



0. Smooth



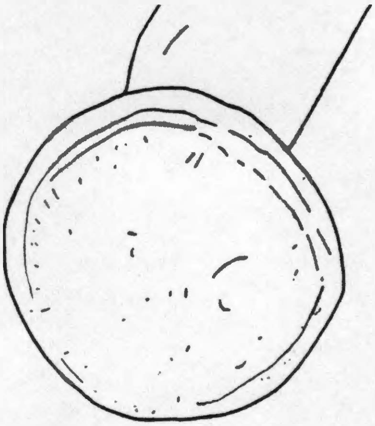
2. Largely obliterated 50% of surface



1. Pitting or accretions

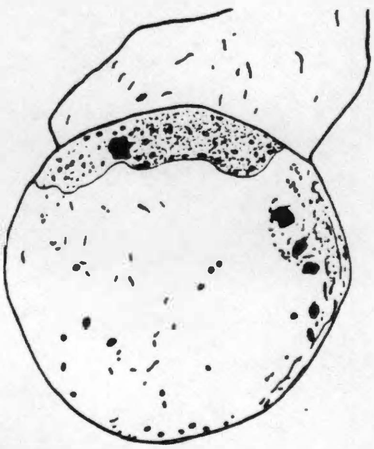
PROXIMAL RADIUS

A. Superior Surface of Head

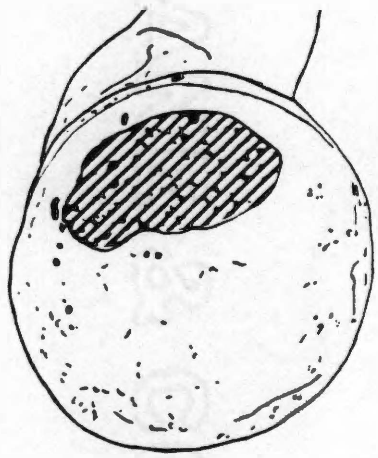


0. Smooth

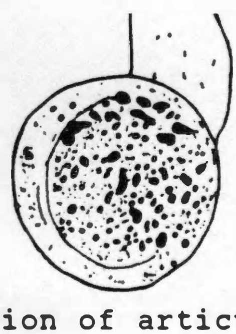
1. Pitting or bony accretions



2. Bony accretions or
pitting 25% of surface



3. Eburnation

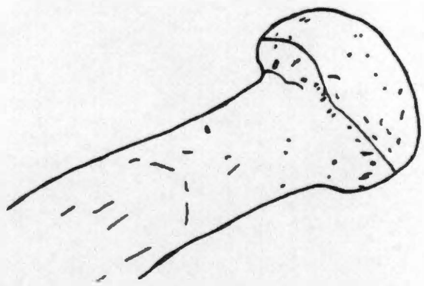


4. Destruction of articular surface

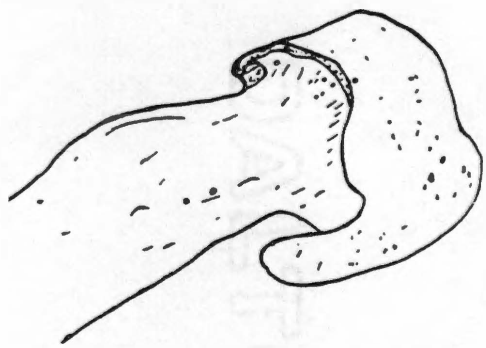
= eburnation

PROXIMAL RADIUS

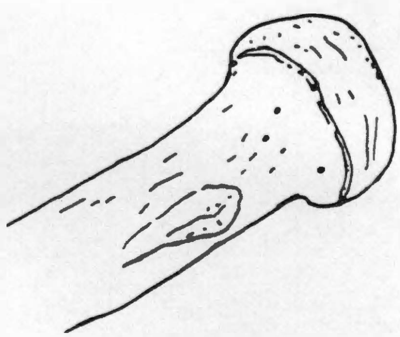
B. Inferior surface of Head



0. Smooth



2. Lip projects sharply inferiorly beyond original surface



1. Double edge visible

APPENDIX C

STATISTICAL DATA FOR ELBOW
FREQUENCY OF INVOLVEMENT
OF ORIGINAL VARIABLES

TABLE 8.17

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT
SEX AND SIDE COMBINED

Variable	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	208	45.19	51.44	03.37	00.00	380	95.53	02.89	01.58	00.00	203.629	.000	2
HLTR	279	17.56	64.87	17.56	00.00	387	29.97	51.42	18.60	00.00	15.320	.000	2
HOF	280	53.93	45.36	00.71	00.00	385	89.09	10.91	00.00	00.00	105.424	.000	2
HCF	276	43.12	55.07	01.81	00.00	387	68.22	31.78	00.00	00.00	45.650	.000	2
HAST	273	06.23	88.64	05.13	00.00	386	06.74	92.23	01.04	00.00	10.092	.006	2
HASC	245	06.94	86.53	06.12	00.41	386	06.74	91.97	01.04	00.26	13.484	.004	3
UCML	216	26.39	53.24	20.37	00.00	360	68.33	30.56	01.11	00.00	123.025	.000	2
UOML	208	25.00	52.88	18.75	03.37	362	68.23	30.11	01.10	00.55	126.038	.000	3
URML	207	55.56	43.00	01.45	00.00	365	83.56	15.62	00.82	00.00	53.397	.000	2
UASC	238	03.36	88.66	07.98	00.00	366	03.55	91.26	05.19	00.00	1.910	.385	2
UA	232	02.16	93.53	04.31	00.00	367	03.00	94.28	02.72	00.00	1.456	.483	2
UASR	236	05.51	94.49	00.00	00.00	365	08.22	90.14	01.64	00.00	5.647	.059	2
RSSH	213	06.10	79.81	13.15	00.94*	345	02.32	95.36	02.32	00.00	35.739	.000	4
RIMH	163	16.56	71.17	12.27	00.00	334	44.31	51.80	03.89	00.00	42.598	.000	2

* This figure is for the combined 3 and 4 degrees, separately the percentages are .47% for 3 and .47% for 4.

TABLE 8.18

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT
BY SEX

Variable	Female												
	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	102	44.12	52.94	02.94	00.00	172	95.93	02.33	01.74	00.00	100.341	.000	2
HLTR	135	17.04	67.41	15.56	00.00	176	27.27	55.11	17.61	00.00	5.610	.061	2
HOF	138	58.70	39.86	01.45	00.00	175	92.57	07.43	00.00	00.00	51.284	.000	2
HCF	136	46.32	52.21	01.47	00.00	176	70.45	29.55	00.00	00.00	20.034	.000	2
HAST	134	05.22	89.55	05.22	00.00	175	06.86	92.00	01.14	00.00	4.719	.094	2
HASC	121	06.61	85.12	07.44	00.83	176	06.82	93.18	00.00	00.00	15.068	.002	3
UCML	107	34.58	42.06	23.36	00.00	165	78.79	20.61	00.61	00.00	66.114	.000	2
UOML	103	32.04	45.63	17.48	04.85	164	78.05	20.12	00.61	01.22	64.429	.000	3
URML	109	63.30	34.86	01.83	00.00	164	89.02	10.98	00.00	00.00	26.724	.000	2
UASC	116	06.03	90.52	03.45	00.00	167	05.99	87.43	06.59	00.00	1.346	.510	2
UA	114	03.51	92.11	04.39	00.00	167	04.79	93.41	01.80	00.00	1.869	.393	2
UASR	117	07.69	92.31	00.00	00.00	165	07.88	90 91	01.21	00.00	1.436	.488	2
RSSH	105	08.57	79.05	11.43	00.95*	159	03.77	93.71	02.52	00.00	13.912	.003	3
RIMH	80	13.75	71.25	15.00	00.00	155	38.71	56.77	04.52	00.00	19.845	.000	2

* This figure is actually for degree 4; there no incidence of degree 3 for this variable.

TABLE 8.18 (Continued)

Variable													
	Male												
	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	106	46.23	50.00	03.77	00.00	208	95.19	03.37	01.44	00.00	103.030	.000	2
HLTR	144	18.06	62.50	19.44	00.00	211	32.23	48.34	19.43	00.00	9.664	.008	2
HOF	142	49.30	50.70	00.00	00.00	210	86.19	13.81	00.00	00.00	56.362	.000	1
HCF	140	40.00	57.86	02.14	00.00	211	66.35	33.65	00.00	00.00	25.375	.000	2
HAST	139	07.19	87.77	05.04	00.00	211	06.64	92.42	00.95	00.00	5.684	.058	2
HASC	124	07.26	87.90	04.84	00.00	210	06.67	90.95	01.90	00.48	2.952	.399	3
UCML	109	18.35	64.22	17.43	00.00	195	59.49	38.97	01.54	00.00	60.131	.000	2
UOML	105	18.10	60.00	20.00	01.90	198	60.10	38.38	01.52	00.00	66.941	.000	3
URML	98	46.94	52.04	01.02	00.00	201	79.10	19.40	01.49	00.00	33.366	.000	2
UASC	122	00.82	86.89	12.30	00.00	199	01.51	94.47	04.12	00.00	7.991	.018	2
UA	118	00.85	94.92	04.24	00.00	200	01.50	95.00	03.50	00.00	0.358	.836	2
UASR	119	03.36	96.64	00.00	00.00	200	08.50	89.50	02.00	00.00	5.785	.055	2
RSSH	108	03.70	80.56	14.81	00.93	186	01.08	96.77	02.15	00.00	22.123	.000	3
RIMH	83	19.28	71.08	09.64	00.00	179	49.16	47.49	03.35	00.00	22.698	.000	2

TABLE 8.19

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT
BY SIDE

	Left												
	Averbuch					Indian Knoll							
Variable	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	102	48.04	48.04	03.92	00.00	189	98.41	01.06	00.53	00.00	108.686	.000	2
HLTR	135	22.96	60.00	17.04	00.00	192	34.90	45.83	19.27	00.00	7.060	.029	2
HOF	140	60.00	39.29	00.71	00.00	191	91.10	08.90	00.00	00.00	45.677	.000	2
HCF	139	46.04	52.52	01.44	00.00	192	71.88	28.13	00.00	00.00	24.082	.000	2
HAST	134	07.46	87.31	05.22	00.00	192	06.25	92.71	01.04	00.00	5.426	.066	2
HASC	120	08.33	85.83	05.00	00.83	191	06.81	93.19	00.00	00.00	11.816	.008	3
UCML	104	26.92	50.96	22.12	00.00	181	69.61	30.39	00.00	00.00	69.684	.000	2
UOML	99	24.24	51.52	21.21	03.03	182	69.23	30.22	00.00	00.55	73.399	.000	3
URML	96	56.25	42.71	01.04	00.00	183	84.70	15.30	00.00	00.00	27.835	.000	2
UASC	115	04.35	87.83	07.83	00.00	183	04.37	91.80	03.83	00.00	2.229	.328	2
UA	111	01.80	92.79	05.41	00.00	183	03.83	94.54	01.64	00.00	4.147	.126	2
UASR	112	07.14	92.86	00.00	00.00	184	08.15	90.76	01.09	00.00	1.342	.511	2
RSSH	99	06.06	80.81	12.12	01.01*	172	02.91	94.77	02.33	00.00	14.854	.002	3
RIMH	78	15.38	73.08	11.54	00.00	166	43.37	53.61	03.01	00.00	22.158	.000	2

* This figure is actually for degree 4, there is no incidence of degree 3 for this variable.

TABLE 8.19 (Continued)

Variable	Right												
	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	106	42.45	54.72	01.83	00.00	191	92.67	04.71	02.62	00.00	98.569	.000	2
HLTR	144	12.50	69.44	18.06	00.00	195	25.13	56.92	17.95	00.00	8.771	.012	2
HOF	140	47.86	51.43	00.71	00.00	194	87.11	12.89	00.00	00.00	60.714	.000	2
HCF	137	40.15	57.66	02.19	00.00	195	64.62	35.38	00.00	00.00	22.067	.000	2
HAST	139	05.04	89.93	05.04	00.00	194	07.22	91.75	01.03	00.00	5.446	.066	2
HASC	125	05.60	87.20	07.20	00.00	195	06.67	90.77	02.05	00.51	5.859	.119	3
UCML	112	25.89	55.36	18.75	00.00	179	67.04	30.73	02.23	00.00	55.048	.000	2
UOML	109	25.69	54.13	16.51	03.67	180	67.22	30.00	02.22	00.56	54.845	.000	3
URML	111	54.95	43.24	01.80	00.00	182	82.42	15.93	01.65	00.00	26.797	.000	2
UASC	123	02.44	89.43	08.13	00.00	183	02.73	90.71	06.56	00.00	0.291	.865	2
UA	121	02.48	94.21	03.31	00.00	184	02.17	94.02	03.80	00.00	0.080	.961	2
UASR	124	04.03	95.97	00.00	00.00	181	08.29	89.50	02.21	00.00	5.106	.078	2
RSSH	114	06.14	78.95	14.04	00.88	173	01.73	95.95	02.31	00.00	21.126	.000	2
RIMH	85	17.65	69.41	12.94	00.00	168	45.24	50.00	04.76	00.00	20.737	.000	2

TABLE 8.20

ELBOW: FREQUENCY OF THE DEGREE OF INVOLVEMENT
BY SIDE AND SEX

Male Left													
	Averbuch					Indian Knoll							
Variable	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	51	50.98	45.10	03.92	00.00	104	99.04	00.96	00.00	00.00	56.626	.000	2
HLTR	69	23.19	55.07	21.74	00.00	105	39.05	40.00	20.95	00.00	5.266	.072	2
HOF	71	54.93	45.07	00.00	00.00	104	87.50	12.50	00.00	00.00	24.433	.000	1
HCF	71	45.07	53.52	01.41	00.00	105	70.48	29.52	00.00	00.00	12.240	.002	2
HAST	66	09.09	86.36	04.55	00.00	105	05.71	93.33	00.95	00.00	3.112	.211	2
HASC	58	10.34	87.93	01.72	00.00	104	06.73	92.27	00.00	00.00	2.515	.284	2
UCML	55	21.82	63.64	14.55	00.00	97	62.89	37.11	00.00	00.00	31.721	.000	2
UOML	52	19.23	57.69	21.15	01.92	98	62.24	37.76	00.00	00.00	38.919	.000	3
URML	46	50.00	50.00	00.00	00.00	100	81.00	19.00	00.00	00.00	14.776	.000	1
UASC	61	01.64	88.52	09.84	00.00	99	02.02	94.95	03.03	00.00	3.306	.192	2
UA	57	00.00	94.74	05.26	00.00	99	02.02	95.96	02.02	00.00	2.344	.310	2
UASR	57	05.26	94.74	00.00	00.00	100	08.00	91.00	01.00	00.00	1.013	.603	2
RSSH	49	04.08	81.63	14.29	00.00	94	02.13	95.74	02.13	00.00	8.710	.013	2
RIMH	39	17.95	76.92	05.13	00.00	90	48.89	48.89	02.22	00.00	11.057	.004	2

TABLE 8.20 (Continued)

Variable	Male Right												
	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	55	41.82	54.55	03.64	00.00	104	91.35	05.77	02.88	00.00	49.757	.000	2
HLTR	75	13.33	69.33	17.33	00.00	106	25.47	56.60	17.92	00.00	4.325	.115	2
HOF	71	43.66	56.34	00.00	00.00	106	84.91	15.09	00.00	00.00	33.441	.000	1
HCF	69	34.78	62.32	02.90	00.00	106	62.26	37.74	00.00	00.00	14.535	.001	2
HAST	73	05.48	89.04	05.48	00.00	106	07.55	91.51	00.94	00.00	3.489	.175	2
HASC	66	04.55	87.88	07.58	00.00	106	06.60	88.68	03.77	00.94	2.046	.563	3
UCML	54	14.81	64.81	20.37	00.00	98	56.12	40.82	03.06	00.00	29.722	.000	2
UOML	53	16.98	62.26	18.87	01.89	100	58.00	39.00	03.00	00.00	29.446	.000	3
URML	52	44.23	53.85	01.92	00.00	101	77.23	19.80	02.97	00.00	18.487	.000	2
UASC	61	00.00	85.25	14.75	00.00	100	01.00	94.00	05.00	00.00	5.076	.079	2
UA	61	01.64	95.08	03.28	00.00	101	00.99	94.06	04.95	00.00	0.380	.827	2
UASR	62	01.61	98.39	00.00	00.00	100	09.00	88.00	03.00	00.00	5.692	.058	2
RSSH	59	03.39	79.66	15.25	01.69	92	00.00	97.63	02.17	00.00	14.428	.002	3
RIMH	44	20.45	65.91	13.64	00.00	89	49.44	46.07	04.49	00.00	11.682	.003	2

TABLE 8.20 (Continued)

	Female Left												
	Averbuch				Indian Knoll								
Variable	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	51	45.10	50.98	03.92	00.00	85	97.65	01.18	01.18	00.00	52.207	.000	2
HLTR	66	22.73	65.15	12.12	00.00	87	29.89	52.87	17.24	00.00	2.345	.310	2
HOF	69	65.22	33.33	01.45	00.00	87	95.40	04.60	00.00	00.00	23.893	.000	2
HCF	68	47.06	51.47	01.47	00.00	87	73.56	26.44	00.00	00.00	12.001	.002	2
HAST	68	05.88	88.24	05.88	00.00	87	06.90	91.95	01.15	00.00	2.770	.250	2
HASC	62	06.45	83.87	08.06	01.61	87	06.90	93.10	00.00	00.00	8.776	.032	3
UCML	49	32.65	36.73	30.61	00.00	84	77.38	22.62	00.00	00.00	38.097	.000	2
UOML	47	29.79	44.68	21.28	04.26	84	77.38	21.43	00.00	01.19	35.902	.000	2
URML	50	62.00	36.00	02.00	00.00	83	89.16	10.84	00.00	00.00	14.302	.001	2
UASC	54	07.41	87.04	05.56	00.00	84	07.14	88.10	04.76	00.00	0.048	.976	2
UA	54	03.70	90 74	05.56	00.00	84	05.95	92.86	01.19	00.00	2.504	.286	2
UASR	55	09.09	90.91	00.00	00.00	84	08.33	90.48	01.19	00.00	0.678	.713	2
RSSH	50	08.00	80.00	10.00	02.00*	78	03.85	93.59	02.56	00.00	6.239	.101	3
RIMH	39	12.82	69.23	17.95	00.00	76	36.84	59.21	03.95	00.00	11.407	.003	2

* This figure is actually for degree 4, there is no incidence of degree 3 for this variable.

TABLE 8.20 (Continued)

Variable	Female Right												
	Averbuch					Indian Knoll							
	N	0	1	2	3	N	0	1	2	3	X2	Prob	DF
HTMM	51	43.14	54.90	01.96	00.00	87	94.25	03.45	02.30	00.00	49.057	.000	2
HLTR	69	11.59	69.57	18.84	00.00	89	24.72	57.30	17.98	00.00	4.475	.107	2
HOF	69	52.17	46.38	01.45	00.00	88	89.77	10.23	00.00	00.00	28.093	.000	2
HCF	68	45.59	52.94	01.47	00.00	89	67.42	32.58	00.00	00.00	8.336	.015	2
HAST	66	04.55	90.91	04.55	00.00	88	06.82	92.05	01.14	00.00	2.026	.363	2
HASC	59	06.78	86.44	06.78	00.00	89	06.74	93.26	00.00	00.00	6.216	.045	2
UCML	58	36.21	46.55	17.24	00.00	81	80.25	18.52	01.23	00.00	30.328	.000	2
UOML	56	33.93	46.43	14.29	05.36	80	78.75	18.75	01.25	01.25	29.695	.000	3
URML	59	64.41	33.90	01.69	00.00	81	88.89	11.11	00.00	00.00	12.534	.002	1
UASC	62	04.84	93.55	01.61	00.00	83	04.82	86.75	08.43	00.00	3.176	.204	2
UA	60	03.33	93.33	03.33	00.00	83	03.61	93.98	02.41	00.00	0.116	.994	2
UASR	62	06.45	93.55	00.00	00.00	81	07.41	91.36	01.23	00.00	0.830	.660	2
RSSH	55	09.09	78.18	12.73	00.00	81	03.70	93.83	02.47	00.00	7.741	.021	2
RIMH	41	14.63	73.17	12.20	00.00	79	40.51	54.43	05.06	00.00	9.094	.011	2

VITA

Lorna Kathryn Collins Pierce was born in Union City, Tennessee on October 23, 1937. She attended elementary schools in Arkansas and Oklahoma, graduating from high school in Jonesboro, Arkansas in June 1955. In September of that year she entered Hendrix College and graduated from that institution in June 1959 with a Bachelor of Arts degree in Liberal Arts.

After a year's employment with the Red Cross during which time she was stationed in Korea, she married and reared two sons. In 1978 she entered San Jose State University and received a Bachelor of Arts in Anthropology in 1980 and a Masters of Arts in 1982. She entered the University of Tennessee Graduate School in 1982 and received the Doctor of Philosophy degree in Anthropology in 1987.

The author is a member and past president of the Santa Clara County Archaeological Society, and is currently a member of the Society for California Archaeology, the Human Biology Council, the American Association of Physical Anthropologists, and the American Association of University Women. She is associated with Pierce Consulting of Santa Clara, California and with Archaeological Resource Management of San Jose, California.